SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MAY 1915.

CONTENTS.

GENERAL PHYSICS.

PAGE
517. Comparison of Celestial Angular Distances. *G. Bigourdan* 209
518. Direct-reading Compression Vacuum-meter. *H. J. Reiff* 209
519. Apparatus for Class Work in Practical Physics. *G. F. C. Searle* 209
520. Simplification of Involution and Evolution Processes. *E. Chappell* 210
521. Practical Harmonic Analysis. *A. Russell* 210
522. Thermal Method of Determining the Elastic Limit. *C. J. Droujinine* 211
523. Strength of an Ideal Column. *F. T. Chapman* 211
524. Demonstration of Strain-hardening in Steel. *R. W. Chapman* 212
525. Endurance of Steel. *W. C. Popplewell* 212
526. Deformation of Rubber: Action of Electrostatic Field. *L. Bouchet* 213
527. Measurement of Time and Tests of Timepieces 213
528. Harmonic Toothed-Wheel: Application to Chronometer. *A. Guillet* 213
529. Formation of Standing Waves. *A. H. Gibson* 214
530. Measurement of Pressure in Soap-bubble. *J. P. Kuenen* 214
531. Similarity in Relation to Surface Friction of Fluids. *T. E. Stanton & J. R. Pannell* 215
532. Flow of Fluids through Smooth Pipes. *C. H. Lees* 215
533. The Principle of Similitude. *Rayleigh* 216
534. Co-operation between Physicist and Engineer. *C. Hering* 217
535. Types of United States Storms. *E. H. Bowie & R. H. Weightman* 218
536. Eddy Motion in the Atmosphere. *G. I. Taylor* 219
537. Seismic Observations recorded in Switzerland. *A. de Quervain* 219
538. The Italian Earthquake of January 13, 1915. *B. Galitzine* 220
539. Formation of Oceans and Primitive Continents. *E. Belot* 220
540. Radiometric Measures of 110 Stars. *W. W. Coblentz* 220
541. Determination of Electronic Charge from Absorption of Solar Radiation. *L. V. King* 221

LIGHT.

PAGE
542. The Polyscope and its Projection. *A. W. Bickerton* 222
543. Refractive Indices of Minute Crystal Grains. *F. E. Wright* 222
544. Rotating Sector in Photographic Photometry. *A. E. Weber* 223
545. Experiments with Spectro-flicker Photometer. *H. Bender* 223
546. Mixed Specular and Diffuse Reflection. *P. G. Nutting* 223
547. Physical Photometry. *H. E. Ives* 224
548. Measuring the Focal Length of Lens. *T. Smith* 224
549. The Visibility of Radiation. *P. G. Nutting* 224
550. Ultra-violet Wave-lengths of the Iron Spectrum. *K. Burns* 224
551. Spectra of Helium and Hydrogen. *E. J. Evans* 225
552. Spectra of Hydrogen and Helium. *T. R. Merton* 225
553. Comparison of Wave-length of Neon Line (λ6402) with that of Cadmium Line (λ6438). *T. Takamine* 226
554. Displacements in Spectral Lines. *G. V. Morrow* 226
555. Widening of Spectrum Lines. *Rayleigh* 227
556. Anomalous Zeeman-effect in Satellites of Violet Line of Mercury. *H. Nagaoka & T. Takamine* 227
557. New Series in Spectrum associated with Helium. *A. Fowler* 228
558. Spectra of Ordinary Lead and Lead of Radio-active Origin. *T. R. Merton* 228
559. Spectrum of Palladium. *E. Paulson* 229
560. Light Absorption and Fluorescence. *E. C. C. Baly* 229
561. X-ray Fluorescence and the Quantum Theory. *C. G. Barkla* 230
562. Relation between X-ray Wave-lengths and Absorption Coefficients. *W. H. Bragg* 230
563. Problems of Radiation. *C. G. Barkla* 232
564. Boundary Phenomena with Röntgen Rays. *J. Laub* 232
565. Boundary Phenomena with Röntgen Rays. *J. Laub* 233
566. Boundary Phenomena with Röntgen Rays. *J. Laub* 233
567. Dispersion of Röntgen Radiation at Lead Boundary. *J. Laub* 234
568. Active Deposit of Radium. *E. M. Wellisch* 234
569. Tracks of *a*-Particles in Films. *S. Kinoshita & H. Ikeuti* 235
570. Condensation of Thorium and Radium Emanations. *A. Fleck* 236
571. Radium Emanation in Petroleum. *K. Fuji* 237
572. Radio-activity of Mineral Springs. *D. Isitani* 237

HEAT.

573. The Leduc Effect in some Metals and Alloys. *A. W. Smith & A. W. Smith* 238
574. Specific Heats of Liquids and Vapours. *S. Pagliani* 238
575. Electrically Heated Full Radiator. *H. B. Keene* 239
576. Vapour Pressures of Oxygen. *H. K. Onnes, C. Dorsman & G. Holst* 240
577. Vapour Pressures of Nitrogen. *C. A. Crommelin* 240
578. Rectilinear Diameter of Nitrogen. *E. Mathias, H. K. Onnes & C. A. Crommelin* 241

ELECTRICITY AND MAGNETISM.

579. Electricity in the Atom. *V. K. Lebedinski* 242
580. Frictional Electricity on Insulators and Metals. *W. M. Jones* 243
581. Electromagnetic Field in an Anisotropic Medium. *M. Francesco* 243

PAGE
582–583. 244
584. Atmospheric Potential Gradient at Kew. *C. Chree* 244
585. Photo-active Cells with Fluorescent Electrolytes. *G. E. Thompson* 245
586. On Ionisation. *J. J. Thompson* 245
587. Ionisation of Metals by Kathode Rays. *N. Campbell* 246
588. Method of Investigating Thermionic Emission. *F. L. Hopwood* 247
589. Analysis of Gases after Passage of Discharge. *A. C. G. Egerton* 247
590. Electric Field in the Hittorf-Crooks Space. *A. Lo Surdo* 248
591. Most Effective Adjustment of an Induction-coil. *E. T. Jones* 249
592. Mechanical Analogue of Coupled Circuits. *T. R. Lyle* 249
593. 250
594. Valve-cell Rectifier. *H. Greinacher* 250
595. Wiedmann Phenomenon in Nickel Wires. *T. Gnessotto & V. Mattioli* ... 250
596. Magnetic Properties of Manganese Steel. *R. A. Hadfield & B. Hopkinson* 250
597. Process for Obtaining Radiographs upon Metal. *Rivier & Dupoux* 251
598. Electromagnets for Surgical Purposes. *Brandt & D. du Rousset* 251

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

599. Diffusion of Hydrogen through Palladium. *A. Holt* 252
600. Salts Coloured by Kathode Rays. *E. C. C. Baly* 252
601. Notes on Glass 252
602. Silicised Carbon. Silfrax. *F. J. Tone* 253
603. Electric Synthesis of Colloids. *J. Mukhopâdhyâya* 254
604. Chemical Relations of Iron, Tungsten, Nickel, and Carbon. *J. O. Arnold & A. A. Read* 254
605. Influence of Nitrogen on Properties of Iron. *N. P. Tchijevski* 256
606. Iron and Nitrogen. *N. P. Tchijevski* 256
607. Recrystallisation of Deformed Iron. *C. Chappell* 256
608. Improvements in Case-hardening Practice. *H. L. Heathcote* 257
609. Alloys with Remarkable Properties at High Temperatures. *L. Guillet* ... 258
610. Experiments on Allotropy of Iron. *C. Benedicks* 258
611. Titanium and its Effects on Steel. *G. F. Comstock* 260
612. Allotropy of Cadmium. V. *E. Cohen & W. D. Helderman* 260
613. Physical Properties of Isotopes. *F. A. Lindemann* 260
614. Action of Lead, Copper, and Aluminium on Water. *W. P. Jorissen* 261
615. Electrode and Diffusion Potentials. *G. W. Moffitt* 261
616. Reproducibility of the Copper Electrode. *F. H. Getman* 262
617. Electrolytic Deposition of Copper-Tin Bronzes. *R. Kreman, C. T. Suchy, J. Lorber, & R. Maas* 262
618. Electrolytic Separation of Rare Earths. *L. M. Dennis & B. J. Lemon* ... 263
619. Electrodeposition of Lead. *F. C. Mathers* 263
620. Electro-deposition of Tin. *F. C. Mathers & B. W. Cockrum* 264
621. Sources of Impurities in Kathode Copper. *L. Addicks* 264
622. Electrolytic Separation of Zn, Cu, and Fe from A_3. *A. K. Balls & C. C. McDonnell* 264

AUTHORS' INDEX

Addicks, L., 621.
Arnold, J. O., 604.
Balls, A. K., 622.
Baly, E. C. C., 560, 600.
Barkla, C. G., 561, 563.
Bates, S. J., 593.
Belot, E., 539.
Bender, H., 545.
Benedicks, C., 610.
Bickerton, A. W., 542.
Bigourdan, G., 517.
Bouchet, L., 526.
Bowie, E. H., 535.
Bragg, W. H., 562.
Brandt, 598.
Burns, K., 550.
Campbell, N., 587.
Chapman, F. T., 523.
Chapman, R. W., 524.
Chappell, C., 607.
Chappell, E., 520.
Chree, C., 584.
Coblentz, W. W., 540.
Cockrum, B. W., 620.
Cohen, E., 612.
Comstock, G. F., 611.
Crommelin, C. A., 577, 578.
Dean, G. R., 583.
Dennis, L. M., 618.
Dorsman, C., 576.
Droujinine, C. J., 522.
Dupoux, 597.
Egerton, A. C. G., 589.
Evans, E. J., 551.
Fleck, A., 570.
Fowler, A., 557.
Francesco, M., 581.
Fuji, K., 571.
Galitzine, B., 538.
Getman, F. H., 616.
Gibson, A. H., 529.
Gnesotto, T., 595.
Greinacher, H., 594.
Guillet, A., 528.
Guillet, L., 609.
Hadfield, R. A., 596.
Heathcote, H. L., 608.
Helderman, W. D., 612.
Hering, C., 534.
Holst, G., 576.
Holt, A., 599.
Hopkinson, B., 596.
Hopwood, F. L., 588.
Ikeuti, H., 569.
Isitani, D., 572.
Ives, H. E., 547.
Jones, E. T., 591.
Jones, W. M., 580.
Jorissen, W. P., 614.
Keene, H. B., 575.
King, L. V., 541.
Kinoshita, S., 569.
Kreemann, R., 617.
Kuenen, J. P., 530.
Laub, J., 564, 565, 566, 567.
Lebedinski, V. K., 579.
Lees, C. H., 532.
Lemon, B. J., 618.
Lindemann, F. A., 613.
Lorber, J., 617.
Lo Surdo, A., 590.
Lyle, T. R., 592.
Maas, R., 617.
McDonnell, C. C., 622.
Mathers, F. C., 619, 620.
Mathias, E., 578.
Mattioli, V., 595.
Merton, T. R., 552, 558.
Moffitt, G. W., 615.
Morrow, G. V., 554.
Mukhopâdhyâya, J., 603.
Nagaoka, H., 556.
Nutting, P. G., 546, 549.
Onnes, H. K., 576, 578.
Pagliani, S., 574.
Pannell, J. R., 531.
Paulson, E., 559.
Popplewell, W. C., 525.
de Quervain, A., 537.
Rayleigh, 533, 555.
Read, A. A., 604.
Reiff, H. J., 518.
Rivier, 597.
du Rousset, D., 598.
Russell, A., 521.
Searle, G. F. C., 519.
Smith, A. W., 573.
Smith, T., 548.
Stanton, T. E., 531.
Suchy, C. T., 617.
Surdo, A. Lo, 590.
Takamine, T., 553, 556.
Taylor, G. J., 536.
Tchijevski, N. P., 605, 606.
Thompson, G. E., 585.
Thomson, J. J., 582, 586.
Tone, F. J., 602.
Vinal, G. W., 593.
Weber, A. E., 544.
Weightman, R. H., 535.
Wellisch, E. M., 568.
Wright, F. E., 543.

SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MAY 1915.

GENERAL PHYSICS.

517. *Differential Comparison of Celestial Angular Distances.* **G. Bigourdan.** (Comptes Rendus, 160. pp. 111–114, Jan. 25, 1915.)—An instrument is designed for the special purpose of obtaining differential measurements of angular distances between stars, for such investigations as the determination of the constant of refraction. Two telescopes are employed, mounted on independent axes on either side of a strong metal disc; the disc is provided with an axis in its own plane, and the whole is mounted equatorially with the disc axis in the position usually occupied by the main telescope. Each of the subsidiary telescopes is fitted with micrometer eyepiece, and the whole is to be very strongly built and enveloped with insulating material to minimise changes due to temperature, etc. C. P. B.

518. *New Direct-reading Compression Vacuummeter.* **H. J. Reiff.** (Zeitschr. Instrumentenk. 34. pp. 97–106, April, 1914.)—An article on the McLeod gauge and the various modifications which have been suggested by Zehnder, Gaede, Rehden, G. W. A. Kahlbaum, and the author, chiefly for the purpose of reducing the length of the tubes, of doing away with the elastic tubing, and of making the instrument direct-reading. The author mounts the gauge on a board which can be turned, in its vertical plane, about a steel cone through an angle of 90°. In the most recent direct-reading type for several decadic ranges the volume tube is normally horizontal (instead of vertical), so that the zero does not change its position with varying degrees of compression. Marks I, II, III, IV on the volume tube correspond to the compression-degrees 0·0001, 0·001, 0·01, 0·1, and indicate the limits to which the mercury is to be driven from the receptacle for the respective ranges. For technical work, lamp evacuation, *e.g.* these marks are distinguished by different colours. The new gauge is made by A. Pfeiffer, of Wetzlar. H. B.

519. *Apparatus for Class Work in Practical Physics.* **G. F. C. Searle.** (Phys. Soc., Proc. 27. pp. 119–127; Disc. 128, Feb., 1915.)—Apparatus for a number of experiments is described briefly, and references indicate where fuller information may be found. The experiments include: (1) Harmonic

motion of a rigid body suspended by a torsion wire. (2) Determination of g by a rigid pendulum. (3) Determination of Poisson's ratio for indiarubber. (4) Two methods of measuring the surface tension of spherical soap films. (5) A simple viscometer for very viscous liquids. (6) Experiments with a prism of small angle. (7) Revolving-table method of determining the curvature of spherical surfaces. (8) Experiments illustrating flare spots in photography. (9) Determination of the effective aperture of a photographic lens. (10) The comparison of nearly equal electrical resistances. Of these, all but (2) and (3) have previously been dealt with. In (2) the moment of inertia of the rigid pendulum about an axis through its centre of gravity and parallel to the knife-edge is determined by suspending the pendulum from a torsion wire by means of a simple stirrup, so that the rod of the pendulum is horizontal. The periodic time of the torsional vibrations is found in this case, and when an inertia bar of calculable moment of inertia is attached to the torsion wire in place of the stirrup and pendulum. The distance of the centre of gravity of the pendulum from the knife-edge is found by balancing the pendulum on a fulcrum. g is then easily calculated. For (3) an indiarubber tube is used. The lower end is closed by a solid plug; in the upper end a glass tube of small bore is inserted. The distance between the end of the plug and that of the glass tube is taken as l. The indiarubber and glass tubes contain water, and the change in the position of the meniscus when the rubber tube is stretched, is observed. From the resulting curve the value of dv/dl is obtained. Proper clamps are provided for securing the rubber tube to the plug and to the glass tube, and other fittings allow these clamps to be held in position on a vertical steel rod. Scales for reading l and the position of the meniscus are provided. Let the length of a tube of circular section be l, its internal radius r, and its internal volume v, so that $v=\pi l r^2$. Let the length be slightly increased so that l becomes l', r becomes r', and v becomes v'. Then, if σ is Poisson's ratio, $\sigma=\frac{1}{2}\left[1-(l/v)\,.\left\{(v'-v)/(l'-l)\right\}\right]$. For infinitesimal changes we have $\sigma=\frac{1}{2}[1-(l/v)\,.(dv/dl)]$. The value of σ is about 0·47. [See Abs. 388 (1915).] A. W.

520. *Simplification of the Arithmetical Processes of Involution and Evolution.* **E. Chappell.** (Roy. Soc., Proc. 91. pp. 242–244, April 1, 1915.)—In performing evolution and involution by logarithms the arithmetical processes simplify to multiplication and division. A second application of logarithms, however, reduces these processes finally to addition and subtraction. The double application of logarithms would be greatly simplified in many cases if tables of the logarithms of the logarithms of numbers were constructed. For example, if $a^n=b$, then $n\log a=\log b$ and $\operatorname{loglog} a+\log n=\operatorname{loglog} b$. Hence from the tables we find $\operatorname{loglog} a$ and $\log n$ directly, and adding them together we get $\operatorname{loglog} b$, from which b can be found. The author writes $\operatorname{loglog} b$ as $\operatorname{lolog} b$, the antilogarithm of b as $\operatorname{illog} b$, and the inverse function of the lolog as the illolog. The difficulty of taking the logarithm of a negative number is got over by omitting the minus quantity and printing the result on red paper. A. R.

521. *Practical Harmonic Analysis.* **A. Russell.** (Phys. Soc., Proc. 27. pp. 149–169; Disc., 169–170, Feb., 1915.)—Making the assumption that the graph of a periodic function is given, the problem of the best way of determining the Fourier constants in the series equation which represents it is considered. The ordinary method of procedure is to neglect all the harmonics above a certain order and determine the coefficients of the harmonic

terms by making the curve represented by this equation pass through a number of arbitrarily selected points on the given curve. This is the method used, for instance, by Runge and Grover. A serious defect in this solution is that the values found for the amplitudes of the harmonics, more especially for the higher harmonics, may be very different from their true Fourier values. The method gives no indication of the magnitude of these errors. Gauss pointed out many years ago that the solution of this limited problem could be written down at once mathematically, and that it was of importance in certain interpolation problems in astronomy. Another method has been suggested recently by S. P. Thompson. He uses certain series formulæ for finding the Fourier constants. The author suggests other series formulæ of a similar kind. If the given curve be approximately sine-shaped, so that the amplitudes of the higher harmonics are small, this method is both simple and accurate. For distorted waves, however, the lack of accuracy is serious in practice. It has also the drawback that an error made in computing the value of one of the constants may introduce errors in the computed values of the others. The author gives numerical examples to illustrate the accuracy attainable by the use of infinite series formulæ. He concludes by pointing out that in the great majority of cases much the best method of procedure when determining the constants is to evaluate Fourier's integrals by the methods of mechanical quadrature given in books on the calculus of finite differences. In particular he has found that Weddle's rule is admirably adapted for the practical computation of the Fourier integrals. By means of this rule, a new and simple proof of which is given, each constant is determined separately to a high order of accuracy. Numerical examples are given to illustrate this. The series formulæ used by Thompson can be usefully employed either for verifying the values found by mechanical quadrature or for indicating when the higher harmonics cannot be neglected. [See Abs. 895 (1915).] A. W.

522. *Thermal Method of Determining the Elastic Limit under Normal Stresses.* **C. J. Droujinine.** (Rev. Soc. Russe de Métal. 1. pp. 230–242, 1913. Rev. de Mét. 11. E. pp. 605–608, Sept., 1914.)—Earlier researches have shown that under tensile stresses the temperature of a specimen decreases until the elastic limit is attained. Above this stress the temperature increases, so that at the elastic limit the minimum temperature of the specimen is recorded. In the earlier part of the test the fall is very slight, and if the recording apparatus is at all sensitive, external influences, such as the presence of the operator, are liable to affect the results. The author has attempted to remove external influences by the use of two similar test-pieces, one of which is subject to the action of the stress while the other is attached to the machine close by. A constantan wire joins the two specimens, and copper wires lead from the ends of the constantan wires to a galvanometer, the whole forming a differential thermo-couple of considerable sensitivity. Under such conditions external changes affect both couples equally and are not recorded on the galvanometer, which, therefore, only records the temperature changes brought about by the effects of the stress on the test-piece. On account of its simplicity and rapidity the method recommends itself for industrial application, although it cannot claim the accuracy of mirror extensometers. F. C. A. H. L.

523. *Strength of an Ideal Column.* **F. T. Chapman.** (Inst. Civ. Eng., Proc. 197. pp. 291–297, 1913–1914.)—Experiments on columns give, for the limiting stable load P, results which differ appreciably from those obtained by Euler's formula, $P = \pi^2 EI/l^2$, because as soon as the stresses in the column exceed the limit of proportionality between stress and strain the coefficient of elasticity, E, ceases to be applicable. Hence various empirical formulæ have been devised in order to express the experimental results. The drawback to these is that in the case of a new material it would be necessary to carry on an extensive series of experiments on many columns of widely differing dimensions in order to determine the necessary empirical constants. But let the coefficient E in Euler's formula be replaced by the expression $(df/ds)/(1-s)$, where s is the strain and df/ds the rate of change of stress with respect to strain, both being deduced from the ordinary stress-strain diagram and referring to a value of stress, f_c, given by P/A, where A is the cross-section of the column. The value of $(1-s)$ is generally inappreciably different from unity, and the expression given above, therefore, reduces to df/ds, which is not constant, but is a definite function of f_c. Writing I as Ak^2 it is found that, with some approximations, $l/nk = \pi\sqrt{(df/ds)/f_c}$ ($n = 1$ for free-ended columns, and 2 for those with fixed ends). Both members of this equation can be determined from compression tests and plotted as functions of f_c, and from these curves the critical load of any column can be readily determined. The results thus obtained for the cast-iron columns tested by Hodgkinson agreed well with his experiments, while those given by the ordinary Euler formula differed greatly at the higher values of f_c.

J. W. T. W.

524. *Demonstration of Strain-hardening in Steel.* **R. W. Chapman.** (Nature, 94. p. 589, Jan. 28, 1915.)—A tensile test bar was marked by a punch and the marks completely filled out, after which the side was polished. On stressing the bar beyond its elastic limit the polish was destroyed everywhere except just below the punch-marks. At these points the polish was retained and the marks remained distinctly raised above the rest of the surface. A similar phenomenon was observed in a shorter bar treated in the same manner under compression. In this case, however, the punch-marks subsequently became visible as polished depressions. F. C. A. H. L.

525. *Slow Reversals of Stress, and Endurance of Steel.* **W. C. Popplewell.** (Inst. Civ. Eng., Proc. 197. pp. 264–290, 1913–1914.)—As a result of experiments planned to repeat some of Bauschinger's work, succeeded by rotating-beam endurance tests, the following conclusions are reached:—The application of equal alternate tensions and compressions from about the primitive limit to somewhat below the yield-point develops artificial limits which are the same in tension and compression. Lower artificial limits are produced by higher stresses, and by plotting the curve relating them they are found to coincide at a limiting stress which is approximately the same as the limiting stress endured indefinitely in rotating-beam tests. This limiting stress is also probably the same as found by Bauschinger by gradually diminishing the applied stress, although he stopped, not at the extreme end point, but at a slightly higher "natural limit." The author suggests the following scheme for predicting the limiting stress under which steel will endure an indefinite number of reversals. Observe the primitive limit, and the yield-point, for one test-piece. Upon another specimen apply ten reversals of stress just below the primitive limit, then determine the new limits in tension and compression; repeat the experiments on this second test-piece, at six or more successively greater stresses between the primitive and yield

stresses. Plot all of the artificial limits so found, against the applied stresses to obtain the required limiting stress as the point where the artificial limit is equal to the applied stress. Alternate tensions and compressions were applied to test-pieces of the usual tensile-test form with screwed ends, and a small sunk centre in each end screwed up tight against a ball. In the rotating-beam tests the test-piece was of long form supported in bearings at its ends, and carrying a weight at two bearings between the ends, equidistant from the centre. The reduced section, subjected thus to a uniform bending moment, was in the middle, between the two inner bearings. F. R.

526. *Deformation of Rubber under the Action of an Electrostatic Field.* **L. Bouchet.** (Comptes Rendus, 160. pp. 240–242, Feb. 15, 1915.)—The author has already described experiments on the elasticity of rubber at small mechanical pressures [see Abs. 1877 (1914)]. The same apparatus, a rubber cylinder filled with water and immersed in water, is now used to study the deformations under the action of an electrostatic field. The deformations are measured by the rise or fall of water in a capillary tube connected to the inside of the cylinder. The field is produced by potential differences ranging from 550 to 2520 volts between the two water surfaces, and the positions of the meniscus are noted at regular intervals during the two minutes following the creation of the field. During this time the liquid falls, at first rapidly, then gradually approaches a stable state until at the end of 2 mins. the deformation ceases to be appreciable. Under mechanical forces of the same order of magnitude the limit of deformation was reached in 20 secs., hence any deformation after this time may be attributed to the field alone.

The calculated fall of the meniscus for 1260 volts is 0·174 mm., whereas the observed fall is 0·198 mm. at the end of 50 secs., and 0·262 mm. at 120 secs. This discrepancy is not due to heating of the rubber (Joule effect), for the rise of temperature is shown to be negligible. It is supposed that the deformation is due to an electrostatic induction proportional at each instant to an *apparent* dielectric constant. This constant is measured at various intervals of time by an ordinary method, and the values are used to calculate the deformations. The results then agree satisfactorily with the experimental values. T. H.

527. *Measurement of Time and Tests of Timepieces.* (Bureau of Standards, Circular No. 51 [89 pp.], Washington, 1914.)—This is the first circular announcement of the beginning of the testing and certification of watches by the Bureau, and gives the regulations under which such tests will be conducted, the procedure of the tests, the criteria that will be applied to the results of the tests, and the tolerances allowed in the performance of a watch for which a certificate is granted. The frontispiece contains a photograph of the precision mean time clock (Riefler type) used as a standard in the testing. The contents of the pamphlet are divided into 12 sections. The position, isochronism, and temperature tests are described at some length with diagrammatic illustrations, while the section on the use and care of a watch teems with valuable information. Very adequate treatment is accorded to the question of standard time. H. H. Ho.

528. *A Harmonic Toothed-Wheel and its Application in the Construction of a Laboratory Chronometer for Registration by a Uniform and Continuous Movement.* **A. Guillet.** (Comptes Rendus, 160. pp. 235–237, Feb. 15, 1915.)—In watches and timepieces an oscillating mechanism subdivides the time into equal intervals, which are indicated by a hand upon a dial by means of its equal but intermittent displacements. For many purposes a uniform and continuous rotatory movement would be an advantage, and the present paper contains the description of an apparatus designed to this end. The theoretical treatment for such regulation is first given, being then followed by the description of a harmonical toothed-wheel which enables the necessary conditions to be realised. H. H. Ho.

529. *Formation of Standing Waves in an Open Stream.* **A. H. Gibson.** (Inst. Civ. Eng., Proc. 197. pp. 233–263, 1913–1914.)—If an open channel of regular section and slope is of sufficient length, the stream which it conveys will ultimately adopt a constant depth and velocity, determined by the relationship $V = C\sqrt{mi}$, where C is a numerical coefficient depending on the physical characteristics of the channel, m is the hydraulic mean depth, i the slope, and V the mean velocity of flow. Where the breadth of the channel is large compared with its depth, m is sensibly equal to the depth, and denoting this by H the equation becomes $V = C\sqrt{Hi}$. If an obstruction is thrown across such a channel so as to increase the depth, or if a sluice-gate is interposed so as to bank the water up-stream and to reduce the depth immediately down-stream to a value less than H, the flow becomes non-uniform. The depth varies from point to point, and the surface profile is no longer a straight line parallel to the bed of the stream, but depends largely on the slope and roughness of the channel. In a channel of slope so small or having a bottom so rough that the product $iC^2/g < 1$, a steep-fronted "standing wave" will be produced on the down-stream side of such a sluice-gate. In a smooth channel of rapid slope where $iC^2/g > 1$, no such wave can be formed, but the depth down-stream gradually increases to the value H. With an obstruction such as a weir thrown across the stream a standing wave may be formed on the up-stream side of the weir, if the channel is so smooth or the slope so great that $iC^2/g > 1$. The height of the standing wave or "jump" has been the subject of previous theoretical and experimental investigations by Bidone, Darcy, and Bazin, but as very serious discrepancies exist between their measured heights and the theoretical values, the present author has re-investigated the problem with particular reference to the "standing wave" formed below a sluice-gate. A full description of the apparatus and method of experimenting is given. A theoretical investigation of the height of the standing wave has been undertaken, the problem being considered from the point of view of change of momentum rather than of energy, the latter standpoint being adopted by the majority of previous writers. It is pointed out that other writers have erred in estimating the magnitude of the shock loss. Darcy and Bazin's experimental results are now shown by the author to be in accord with theory. The effect of the formation of a standing wave on the discharge from a sluice-gate and the effect of a standing wave behind a weir are then considered.

Illustrative figures and tables accompany the paper. H. H. Ho.

530. *Measurement of the Capillary Pressure in a Soap-bubble.* **J. P. Kuenen.** (K. Akad. Amsterdam, Proc. 17. pp. 946–949, Feb. 27, 1915. Communication No. 145*a* from Phys. Lab., Leiden.)—In attempting to increase the accuracy of measurement of the comparatively small pressure in a soap-bubble, the author made use of a micromanometer, in which the pressure to be measured acts on a large liquid surface, the latter, when the pressure changes, being displaced over the same distance, just as though the instrument were a simple open water-gauge with two tubes of the same width. It was found, however, that the measurement may become impossible owing to the instability of the condition. Consideration of the equilibrium conditions shows that this phenomenon is connected with the change of volume in the gauge accompanying the displacement of the liquid surface when the pressure is changed. Starting from a condition of equilibrium between the surface tension and the excess of pressure, $p - p_0$, where p_0 is the atmospheric pressure, a virtual change in the bubble, such as diminution of its radius, will be accompanied by increase in the capillary pressure, which will cause the liquid surface in the gauge to descend and thus involve increase of the volume. The condition will certainly be unstable if this increase of volume exceeds the diminution of volume given to the soap-bubble, since in the enlarged volume the pressure of the gas will be smaller, and this decrease will cause further contraction of the bubble. It is shown that rise of temperature or increase of the quantity of gas will make the bubble larger or smaller, according as it is in the stable or the unstable condition. T. H. P.

531. *Similarity of Motion in Relation to the Surface Friction of Fluids.* **T. E. Stanton** and **J. R. Pannell.** (Roy. Soc., Phil. Trans. 214. pp. 199–224, May 26, 1914. Engineering, 117. pp. 710–712, May 22, 1914.)—This paper contains the results of experiments carried out at the National Physical Laboratory on the flow of fluids through pipes of various diameters and over a large range of velocities. Osborne Reynolds in 1882 carried out a previous investigation of a similar nature and obtained the following relation: $\rho d^3/\mu^2 \, . \, dp/dx = f(vd/\nu)$, where v is the mean velocity of flow through the pipe of diam. d, μ is the coefficient of viscosity of the fluid, and ρ its density, $\nu = \mu/\rho$, and dp/dx is the rate of fall of pressure along the pipe. He further concluded that $f(vd/\nu) \propto (vd/\nu)$ for conditions of stream-line motion, while above the critical velocity the relation is expressed by $f(vd/\nu) \propto (vd/\nu)^n$, where n is a constant varying from 1·75 to 2. This latter conclusion is not verified in the present experiments, which show definitely that when the range in speed is considerable the index law fails to represent the results. The flow of air and water through pipes of diam. 0·36 to 2·85 cm. was investigated, while other experiments were made with air and a thick oil for a pipe 10·1 cm. in diam. The value of (vd/ν) was varied from 1250 to 400,000; the change from stream-line to turbulent flow occurred at about 2500. The departure from the index law of Osborne Reynolds for high velocities of flow is shown by the following figures. The value $n = 1{\cdot}72$ was calculated for a pipe of diam. 1·25 cm. by observations at low speeds; using this index it was found that the resistance is underestimated by about 5% at 1000 cm. per sec., by 8·5% per cent. at 2000, and by 15% at 3000 cm. per sec. Some curves are given showing the agreement between the results of previous experiments and those obtained in the present research. The latter are quoted in full in a series of tables. W. F. H.

532. *Flow of Viscous Fluids through Smooth Circular Pipes.* **C. H. Lees.** (Roy. Soc., Proc. 91. pp. 46–53, Nov. 2, 1914.)—The important results obtained by Stanton and Pannell during the last three years [Abs. 1319 (1911) and preceding Abs.] from observations of the flow of air, oil, and water through smooth brass pipes of diams. from 0·3 to 12 cm. at speeds from 5 to 5000 cm. per sec., seem by their accuracy and consistency to justify a re-examination of the subject with a view to the establishment if possible of a connection between the physical properties and mean speed of the fluid, and the diameter, length, and pressure of the pipe, which shall hold with greater

accuracy and over a wider range than the existing formulæ have proved themselves capable of doing. The conclusions arrived at as a result of the present investigation may be summarised as follows:—(1) The difference of pressure $p_0 - p_l$ in dynes per cm.^{2} between two sections distant l cm. from each other along a pipe of diameter d cm. through which a fluid, whose density ρ may be considered constant over the length l, and whose kinematical viscosity is ν, is flowing with mean velocity v, cannot be represented by a single power of the velocity, but requires for its expression a formula of the type $p_0 - p_l = 2\,[l\rho v^2/d]\,[a + b\,(\nu/vd)^n]$, where a, b and n are constants. (2) To the extent to which the Principle of Dynamical Similarity is applicable to the flow of fluid in tubes, a, b and n should be absolute constants applicable to all fluids and all tubes. Stanton and Pannell's results show that over a wide range $a = 0{\cdot}0018$, $b = 0{\cdot}153$, and $n = 0{\cdot}35$. (3) As the velocity and the diameter increases and as the kinematical viscosity decreases the pressure-difference varies more nearly as $l\rho v^2/d$. (4) The effect of temperature on the pressure-difference decreases as the velocity and diameter increase and as the kinematical viscosity decreases. The above formula reproduces the experimental facts at present known much more closely than any previous expression has succeeded in doing. As it has been deduced from experiments on smooth pipes it is not strictly applicable to rough pipes, although measurements on such pipes give results which appear to follow the same general laws as those for smooth pipes. Before greater precision in the laws of flow through such pipes can be attained, it will be necessary to come to some understanding as to the specification and measurement of the degree of roughness of a surface.

[Several misprints occur in the formulæ given in the paper, and the corrected expressions should be sought in the author's corrigenda. The formula given above has the correction inserted.] A. W.

533. *The Principle of Similitude.* **Rayleigh.** (Nature, 95. pp. 66–68, March 18, 1915.)—The author has often been impressed by the scanty attention paid even by original workers in physics to the great principle of similitude. It happens not infrequently that results in the form of "laws" are put forward as novelties on the basis of elaborate experiments, although they might have been predicted *a priori* after a few minutes' consideration. However useful verification may be, whether to solve doubts or to exercise students, this seems to be an inversion of the natural order. One reason for the neglect of the principle may be that, at any rate in its applications to particular cases, it does not much interest mathematicians. On the other hand, engineers, who might make much more use of it than they have done, employ a notation which tends to obscure it. The reference here is to the manner in which gravity is treated. When the question under consideration depends essentially upon gravity, the symbol of gravity (g) makes no appearance, but when gravity does enter into the question at all, g obtrudes itself conspicuously. Some examples, chosen almost at random from various fields, are here given to direct the attention of workers and teachers to the great importance of the principle. Some foreign considerations of a more or less obvious character have been invoked in aid.

In using the method practically, two cautions should be borne in mind. First, there is *no* prospect of determining a *numerical* coefficient from the principle of similarity alone; it must be found, if at all, by further calculation, or experimentally. Secondly, it is necessary as a preliminary step to specify clearly *all* the quantities on which the desired result may reasonably be supposed to depend, after which it may be possible to drop one or more if further consideration shows that in the circumstances they cannot enter. The following are some of the conclusions which are given as arrived at by this method:—(1) Geometrical similarity being presupposed here as always, how does the strength of a bridge depend upon the linear dimension and the force of gravity? In order to entail the same strains, the force of gravity must be inversely as the linear dimension. Under a given gravity the larger structure is weaker. (2) The velocity of propagation of periodic waves on the surface of deep water is as the square root of the wave-length. (3) The periodic time of a tuning-fork, or of a Helmholtz resonator, is directly as the linear dimension. (4) The intensity of light scattered in an otherwise uniform medium from a small particle of different refractive index is inversely as the fourth power of the wave-length. (5) The resolving power of an object-glass, measured by the reciprocal of the angle with which it can deal, is directly as its diameter and inversely as the wave-length of the light. (6) The frequency of vibration of a globe of liquid, vibrating in any of its modes under its own gravitation, is independent of the diam. and directly as the square root of the density. (7) The frequency of vibration of a drop of liquid, vibrating under capillary force, is directly as the square root of the capillary tension and inversely as the square root of the density and as the $\frac{3}{2}$-power of the diameter. (8) The time-constant (*i.e.* the time in which a current falls in the ratio $e:1$) of a linear conducting electric circuit is directly as the inductance and inversely as the resistance, measured in electromagnetic measure. (9) The time-constant of circumferential electric currents in an infinite conducting cylinder is as the square of the diameter.

Eiffel found that the resistance to a sphere moving through air changes its character somewhat suddenly at a certain velocity. The consideration of viscosity shows that the critical velocity is inversely proportional to the diam. of the sphere.

In the Æolian harp, if we may put out of account the compressibility and the viscosity of the air, the pitch (n) is a function of the velocity (v) of the wind and the diam. (d) of the wire. It then follows from similarity that the pitch is directly as v and inversely as d, as was found experimentally by Strouhal. If we include viscosity (ν), the form is $n = v/d \,.\, f(\nu/vd)$, where f is arbitrary. E. H. B.

534. *Co-operation between Physicist and Engineer.* **C. Hering.** (Engineering, 99. pp. 284–285, March 5, 1915. Paper read before the Am. Assoc. for Advancement of Science, Philadelphia, Dec., 1914.)—The relationship between physics and engineering may be stated briefly as follows:—The province of the physicist is to discover physical phenomena; to determine what are known as physical constants, and to find experimentally or analytically the correct quantitative laws of nature governing such phenomena; the engineer then takes these data and endeavours to apply them to useful structures for the benefit of man. Engineering may therefore be properly called applied physics.

Owing to this close relationship between physics and engineering, a co-operation between them becomes mutually important. The physicist in his researches should keep in mind the possible useful applications of his results by the engineer; and the engineer should be able to look to the physicist to determine for him the laws of nature qualitatively and quantitatively, and to state them correctly and reliably; when the engineer cannot depend on the physicist to do this, he sometimes has to make physical researches himself to determine missing quantities or laws—a research which he is generally not so well fitted to undertake.

As the work of the physicist thus forms the very foundation of the structures of the engineer, it is very essential that this foundation be as perfect, complete, and reliable as possible. As an engineer, the author accordingly feels it not improper to call attention to cases in which the work of the physicist was either incomplete, imperfect, misleading, or subject to criticism or friendly suggestions.

For instance, most text-books on physics state that like currents of electricity attract, and unlike repel, each other. This statement sometimes leads to wrong conclusions, and is therefore incorrect. The current in a large conductor may correctly be considered to consist of a large number of filamentary currents or streams of flow, all, of course, in the same direction. Hence, according to the above law, they should attract each other, the result being a higher current density in the centre, and consequently a failure of Ohm's law in large conductors. But this is not the case; hence the statement is wrong or faulty.

The correct statement is that it is the material or mass of the *conductors*, and *not* the *currents per se*, which are attracted or repelled when such currents flow. If, instead of being solid, the large conductor is composed of a bundle of very thin flexible parallel wires, separated a slight distance from each other, they will attract each other, thereby contracting the cross-section of the space originally occupied by them. Thus in a liquid or solid conductor there is a *pinch* as though a *hand grasped* it. The author has also detected a longitudinal stretch in a conductor owing to the mutual repulsion of the lines of force encircling it. Through the faulty statement of this physical law the author was misled into expensive and useless experiments as to a certain electric furnace.

Reference is also made to the prevalent faulty statement as to electromagnetic induction [see Abs. 888 (1908)] and to other points as to units.

E. H. B.

535. *Types of United States Storms and their Average Movements.* **E. H. Bowie** and **R. H. Weightman.** (Monthly Weather Rev., Supplement No. 1. [87 pp.], 1914.)—The paper begins with an account of the general pressure conditions which control the movements of storms across the United States, and goes on to describe the ten different types of storm which are recognised, the name of each type being indicative of the region in which the storms first appear on the United States weather maps. With regard to the most probable direction in which a storm will move, it has been customary in the past to publish paths of greatest frequency for each type. The present paper deals with the matter in a different way. The country is divided into 5-degree squares, and tables are given showing (1) the number of storms of each type which have been found in each individual square in either the 8 a.m. or the 8 p.m. maps during the period dealt with, 1892-1912, and (2) the average movement in distance and direction in the following 24 hours for each of these 5-degree square groups of storms. These data are also exhibited by means of arrows in a very complete set of maps, each type of storm and each month being kept separate. The work has been primarily carried out for the use of forecasters, to give them some indication of the direction in which any particular storm may be expected to travel, and its probable rate of movement.

J. S. Di.

536. *Eddy Motion in the Atmosphere.* **G. I. Taylor.** (Roy. Soc., Phil. Trans. 215. pp. 1–26, 1915.)—It has been known for a long time that the retarding effect of the surface of the earth on the velocity of the wind must be due in some way to eddy motion, but no detailed calculations appear to have been made on the subject. The present paper deals with the effect of a system of eddies on the velocity of the wind and also on the temperature and humidity of the atmosphere. Considering first the propagation of heat in a vertical direction the ordinary conductivity of heat by molecular agitation is extremely small, but a more potent effect may be produced by vertical transference of air which retains its heat as it passes into regions where the potential temperature differs from that of the layer from which it started. It appears, on calculation, that potential temperature will be transmitted upwards through the atmosphere by means of eddies in the same way that temperature is transmitted in a solid of conductivity κ, provided that $\kappa/\rho\sigma = \frac{1}{2}\bar{w}d$; where ρ is the density and σ the specific heat of air, $\bar{w}$ represents the mean vertical velocity of the air in those places where it is moving upwards, and d the average vertical distance traversed by the eddies. κ is termed the "eddy conductivity" of the air. Now, if the temperature distribution in the air at any time is known and the subsequent changes at the base of the atmosphere, the temperature distribution at any later time can be calculated, assuming a value for κ. The theory was put to the test by means of some kite ascents made from the ice-scout ship *Scotia* in the North Atlantic. From these the upper-air temperature distribution was determined; and by tracing back the course of the air over the sea the different temperatures to which the surface layer had been exposed for the preceding few days were approximately obtained. The upper-air temperature distribution was found to agree well with that which would be expected from the theory, and calculation of κ for the individual ascents gave values showing some proportionality to the mean wind velocity. As the eddy motion would naturally be more pronounced on days of strong wind this result is satisfactory.

In the same manner that eddies effect a transference of heat between different parts of the atmosphere, so also will there be a transference of momentum from one air current to another. The velocity of the layer of air in immediate contact with the earth is reduced by the frictional drag, and assuming this reduction of velocity to be communicated to the upper layers by "eddy viscosity," certain relations between the surface and upper wind are worked out. The resulting height-velocity and height-direction curves obtained agree remarkably well with the mean results of observations made with pilot balloons on Salisbury Plain. One noteworthy feature in which the theoretical result agrees with the experimental is that the gradient wind velocity is attained by the actual wind at a less height than that at which the gradient direction is reached. The present theory agrees with the observed facts in several particulars where the previously existing theory of Guldberg and Mohn fails. J. S. Di.

537. *Seismic Observations recorded in Switzerland.* **A. de Quervain.** (Archives des Sciences, 39. pp. 47–58, Jan., 1915.)—In this paper the author describes how it is possible to forecast with tolerable accuracy the scene of an earthquake from observation data obtained at a single station. An example is given from the Zürich Seismological Institute where the earthquake of Oct. 8, 1914, was detected and located in Asia Minor, the forecast being confirmed by telegraph 24 hours later. The various instruments

employed are so constructed as only to register earth movements in particular directions. Each instrument diagram then requires interpretation, the method receiving detailed attention in the paper. From the different speeds of the longitudinal and transverse earth waves it is possible to locate the disturbance centre with an accuracy of 2 to 3 per cent.

The Bosch-Mainka seismograph for recording the two horizontal components is well described, as also the Spindler-Hoyer-Wiechert apparatus for the vertical component. Since for every component accurate timing is essential, this has been secured by a pendulum so arranged as to interrupt the traced line periodically. This pendulum is calibrated from the Eiffel Tower wireless signals. A note is made that the effect of winter storms in the North Sea is such as to render many German seismic observations valueless, an effect almost non-apparent in Switzerland. H. H. Ho.

538. *The Italian Earthquake of January* 13, 1915. **B. Galitzine.** (Comptes Rendus, 160. pp. 247–250, Feb. 15, 1915.)—This paper contains a record of the observations made at the seismic observatory of Pulkowa during the disastrous Italian earthquake of Jan. 13, 1915. The most sensitive of the instruments, however, after recording the first phase were thrown out of action, and only the less sensitive apparatus have given complete data for the whole duration of the various phenomena. The maximum phase was characterised by two groups of distinct maxima, and from the data afforded the actual earth movements have been deduced. The calculated epicentre was found to be in excellent agreement with the actual locality, namely, in the neighbourhood of Avezzano and Pescina, and is additional evidence in favour of localising the epicentre of an earthquake from the observations of a single station. The displacements of surface particles at the first set of maxima were found to be almost perpendicular to the direction of wave propagation. The average speed of the latter was 3·51 km. per sec., while the intensity of the seismic disturbance works out at about the same order as that of the Messina earthquake.

The paper contains a large amount of numerical data. H. H. Ho.

539. *An Orogenic Theory deduced from the Physical Theory of the Formation of Oceans and Primitive Continents.* **E. Belot.** (Comptes Rendus, 160. pp. 139–141, Jan. 25, 1915.)—Previous papers by the same author [see Abs. 828, 1496 (1914)] have dealt with the formation and distribution of primitive oceans and continents, based upon the initial aqueous precipitation taking place in the Antarctic region. This physical theory, however, only applies to the formation of continents at the level — 2000 m., and there still remains to be explained how, upon this fundamental base, the present continental masses have been erected. Extending his theory, the author now shows how the larger marine depressions and mountain chains must be on the continental boundaries, with a tendency to throw the chains towards the continent interior. This also explains the instability of those coast zones which are subject to earthquakes and volcanic activity, as a consequence of the orogenic effort. An experimental illustration of the latter has been designed and is here described. The present theory, based upon the idea of a hydrostatic elevation, is not in contradiction to the theory of depressions, since Lapparent has observed that the majority of known depressions were preceded by elevations. H. H. Ho.

540. *Radiometric Measures of* 110 *Stars.* **W. W. Coblentz.** (Lick Observatory, Bull. No. 266. pp. 104–123, 1915.)—Details are given of laboratory

tests of the sensitivity of thermo-couples for stellar work, and also the measurements of the total radiation from 110 stars, made with the Crossley reflector at the Lick Observatory. The investigation is intended to be a preliminary survey to determine what may be required in the observation of spectral energy curves of stars. For various reasons the thermo-junction method of registration was chosen, and couples of Bi and Bi-Sn alloy were used, attached to the heavy Pt lead wires by fine wires of silver. The galvanometer was specially iron-shielded owing to its proximity to the iron telescope; its sensitivity was adjusted to $i = 1{\cdot}4 + 10^{-10}$ amp. for a single swing of 4 secs. The thermo-elements were kept *in vacuo* by means of metallic calcium in a quartz tube container connected with the apparatus. Elements of Bi-Pt were also used. All the receivers were painted with a mixture of lampblack and platinum black, but some difficulty was found in fixing the coat uniformly close to the edge, and it is thought this may explain some of the differences in sensitiveness. The stellar radiations were admitted to the receiver chamber through a fluorite window. Observations was made by throwing the star image on or off the radiometer receiver by the declination slow-motion screw. As an illustration of the sensitivity obtained, it is stated that the deflection due to the star α Böotis (Arcturus) was 84 mm., indicating a total radiation received from that star slightly greater than $\frac{1}{10000000000}$ candle-metre. Details of the results are given for the 110 stars examined. An interesting conclusion is that the red stars emit from 2 to 3 times as much radiation as blue stars of the same photometric magnitude.

C. P. B.

541. *Determination of Electronic Charge from Absorption of Solar Radiation.* **L. V. King.** (Roy. Soc. Canada, Trans. 8. pp. 59–64, 1914.)—Premising that the bearing of Rayleigh's law of gaseous extinction on some of the fundamental aspects of radiation theory does not seem to have been sufficiently emphasised, the author introduces an interesting analysis of the data given by the Smithsonian observations of solar radiation at various altitudes. The coefficient of attenuation, κ, of radiation of wave-length λ travelling through a gas containing n_0 molcecules per unit volume was given by Rayleigh in 1871 in the form $\kappa = \frac{8}{3}\pi^3(\mu_0^2 - 1)^2\lambda^{-4}/n_0$, μ_0 being the refractive index of the gas.

For an adequate experimental verification of the law recourse must be had to observations of the extinction of solar radiation of different wave-lengths by the earth's atmosphere, and the material for atmospheric transmission given by the Smithsonian records is used for the purposes. The discussion leads the author to conclude that the hypothesis of emission by "quanta" cannot be applied to radiating molecular systems, and that it is difficult to see how Planck's "quantum" can be associated with the individual molecule, at any rate for that system of vibrations which enter into the forced oscillations with consequent re-emission of radiant energy, thus constituting the phenomenon of molecular scattering. In the writer's opinion we might with advantage seek the interpretation of Planck's h in the problem of "black body" radiation in the fact that the radiating units probably perform vibrations under the intramolecular forces and constraints which determine the solid state, while the reaction of the total aggregate of radiating systems must modify the character of the radiation from the original sources before it emerges from the interior of the solid into free space for experimental investigations. [See Abs. 256 (1915).] C. P. B.

LIGHT.

542. *The Polyscope and its Projection.* **A. W. Bickerton.** (Phys. Soc., Proc. 27. p. 177, Feb., 1915.)—The instrument consists of three narrow strips of plate glass arranged as a truncated pyramid. The object end has an area of about $\frac{1}{4}$ sq. in., while the eye end is made very small (about $\frac{1}{20}$ sq. in.) in order to get the max. number of reflections. To get geometrical accuracy in the interfacial angles the edges of the strips overlap instead of being butted. There are three types. In No. 1 the cross-section is an equilateral triangle; this produces the simplest type of pattern. In No. 2 the section is a right-angled isosceles triangle; this produces patterns with two centres of symmetry of eight reflections each and one of four reflections. In the third type the angles are 30°, 60°, and 90°; this produces patterns in which one centre has 12 reflections, one six, and one four. When a group of nondescript objects are viewed through the instrument, a coloured symmetrical pattern may be seen, the character of which changes continuously as the object is moved about. Suitable slides can readily be constructed by mounting pieces of coloured gelatine, fragments of lace, bits of wire, etc., on glass. The designs are best shown projected on a screen, a narrow beam of light from an arc lamp being passed through the polyscope, which is moved about until the max. illumination is obtained. The beam before reaching the object slide passes through a water tank and a ground-glass plate to ensure uniform brightness.

The instrument forms an aid to designers of tiles, floorcloths, fabrics, etc., as an innumerable sequence of designs can be reviewed by the artist in a short time, those which give satisfaction being sketched or photographed.

L. H. W.

543. *Accurate Measurement of Refractive Indices of Minute Crystal Grains by the Petrographic Microscope.* **F. E. Wright.** (Washington Acad. Sci., J. 5. pp. 101–107, Feb. 19, 1915.)—The principal refractive indices of fine crystal particles, measuring 0·01 mm. in diam. or larger, and of medium refringence or birefringence, can be determined by the immersion method with an accuracy of ±0·001 [Abs. 1962 (1914)]. In strongly birefracting minerals and in deeply coloured substances of high refractive index this degree of accuracy is rarely attainable by the immersion method, and can only be approached by a careful observance of certain favourable conditions of observation. These conditions are briefly considered and an attempt is made to ascertain their relative importance in accurate work. It is pointed out (i) that correctly oriented sections should be selected which are normal to at least one principal optic section; (ii) that in case oblique illumination be used, only those pencils of light should be employed whose direction of propagation is included in the plane normal to the principal optical section —in other words, the metal sliding-stop should be so inserted that its front edge is parallel to a principal section; (iii) that with central illumination special weight should be given to the effects along those edges of the grain which trend approximately parallel to the principal section. If these conditions be disregarded the value obtained for the max. refractive index will be too low, the value for the minimum index too high, while that of any inter-

mediate index may be too high or too low. Failure to recognise these factors may lead, especially in the case of strongly birefracting crystal particles, to refractive index determinations which are appreciably in error. A. W.

544. *The Rotating Sector in Photographic Photometry.* **A. E. Weber.** (Ann. d. Physik, 45. 6. pp. 801–838, Nov. 3, 1914. Extract of Dissertation, Munich.)—The correctness of the principle of the rotating sector in ordinary photometry has been established. For photographic work the method has evident advantages, as it can be applied without altering the wave-length of the incident light. But it remains to be shown, particularly for the ultra-violet rays, whether an intermittent exposure of this kind has the same integral effect as a continuous exposure for the same period. The author describes in detail the apparatus used in his experiments on this point, the essential object being to determine whether an exposure reduced in a given fraction by the rotating sector gives the same blackening of the sensitive surface as an equivalent continuous exposure, reduced to the same amount by other means. Experiments on a variety of plates were carried out, and with light of various colours, including invisible rays. The accuracy of the results depends on the consistency of the plate, constancy of light source, precision of alternation method of diminishing light, and the precision of determination of amount of blackening. The probable error from all these sources is computed at 5 to 12 % for individual observations. From the results of these observations, tables of which are presented, the author comes to the conclusion that the method is a simple and correct means of making measurements of ultra-violet light, being independent, within wide limits, of the rate of rotation of the sector, and of the period of exposure. J. S. D.

545. *Experiments with the Lummer-Pringsheim Spectro-flicker Photometer.* **H. Bender.** (Ann. d. Physik, 45. 1. pp. 105–132, Aug. 14, 1914.)—Some experiments are described showing that the results obtained throughout the spectrum by the flicker and acuteness-of-vision methods are substantially the same. The construction of this photometer is also described: its chief feature is the combination of spectrum analysis with a flicker apparatus, which enables the relative brightness in various regions of the spectrum to be compared, one with another, as well as facilitating the comparison of heterochromatic sources. Experiments with this photometer on ten observers having normal vision revealed considerable individual differences, but the minimum of the luminosity curve was throughout near 550 $\mu\mu$; also the observations of the same person at various times were consistent. Two cases of total colour-blindness, giving a maximum near 515 $\mu\mu$, were also investigated. These experiments were made with foveal vision. Further observations were made with portions of the retina lying 20° to 30° outside the direct line of sight. The curves obtained in these circumstances with increasing eccentricity were very similar to those given by the colour-blind subjects, suggesting that total colour-blindness is connected with rod-vision, such as prevails in the peripheral region of the retina. J. S. D.

546. *Mixed Specular and Diffuse Reflection.* **P. G. Nutting.** (Am. Illum. Eng. Soc., Trans. 9. 7. pp. 571–575; Disc., 575–578, 1914.)—The author reviews various methods of studying mixed reflection, such as determining the reflecting power at various angles or using instruments based on the fact that the directly reflected light is polarised. He suggests the use of the terms "glossiness" and "mattness," the former being defined as the ratio of specular to total (specular + diffuse) reflection. The relations for brightness and contrast of illuminated surfaces are given, and it is pointed out how the relative brightness of matt and glossy surfaces may vary according to the direction from which light is received. A case in point is the appearance of ink writing on paper. For a small distant illuminating object print may appear as bright as the paper: with good window lighting the contrast was 4·6 : 1, and with open sky illumination the contrast was 11 : 1. J. S. D.

547. *Physical Photometry.* **H. E. Ives.** (Am. Illum. Eng. Soc., Trans. 10. pp. 101–125, 1915.)—In the early part of this paper the author analyses the chief characteristics of the eye as a measurer of light, and summarises the chief requirements of the ideal physical photometer. These are: (1) Indication by *position* rather than by *quality* (*e.g.* by the reading of a pointer), (2) proportional indication, (3) high sensibility, (4) simple method of response (*e.g.* response directly proportionate to stimulus), (5) constancy, (6) recording capacity, (7) integrating capacity, (8) practicability, and (9) response to different wave-lengths in same relative amounts as the average eye. The available instruments for measuring light by physical and chemical means include radiometers, bolometers, etc., with or without the use of special coloured solutions; selective instruments such as the selenium cell and the photoelectric alkali cell; the photographic plate. The author discusses the merits and prospects of each of these types of apparatus. He finds that the first class, based on the measurement of radiant energy, have so far yielded the most favourable results; within recent years the sensitiveness and practicability of such instruments have been much improved and the author is already using them with good effect in the laboratory for the comparison of lamps of the same class. The selenium cell is at present too uncertain in behaviour, and the sensitiveness to different portions of the spectrum is radically different from that of the eye; also the response is as the square root of the stimulus in most of the spectrum, but in the red is directly proportional to the stimulus. Similar objections apply to the photoelectric alkali-metal cells, no two of which behave alike. The chief value of the photographic method is its power of integrating luminous impressions, and it may prove useful for special purposes. On the other hand, the absolute sensitiveness is affected by many factors; the response throughout the spectrum varies according to the plate, and is in general quite other than that of the eye. J. S. D.

548. *Measuring the Focal Length of a Photographic Lens.* **T. Smith.** (Phys. Soc., Proc. 27. pp. 171–173; Disc., 173–176, Feb., 1915.)—The focal length of a compound lens is obtained solely by focussing on the camera screen the image of a distant object on the lens axis by the complete lens and by each of its components separately. One additional focussing of the same object when the separation of the components is altered determines the focal length of each component. The method is both accurate and quick, and requires only a camera and the lens. AUTHOR.

549. *The Visibility of Radiation.* **P. G. Nutting.** (Phil. Mag. 29. pp. 301–309, Feb., 1915.)—[See Abs. 161 (1915).]

550. *Interferometric Measurements of the Ultra-violet Wave-lengths of the Iron Spectrum.* **K. Burns.** (Comptes Rendus, 160. pp. 243–244, Feb. 15, 1915.)—A redetermination of the ultra-violet arc spectrum of iron between

λλ2851·802 and 3701·082 Å.U., using the red cadmium ray as comparison spectrum. The measurements were taken in Marseilles and the positions calculated at the Bureau of Standards, Washington. In all, 126 lines are recorded, one-twentieth of which have been previously measured. The new measurements accord very well with the old. C. S. G.

551. *Spectra of Helium and Hydrogen.* **E. J. Evans.** (Phil. Mag. 29. pp. 284–297, Feb., 1915.)—The experiments described in this paper have shown (i) that it is possible to observe, in a helium tube giving no trace of the hydrogen lines, the first member (λ4686) of the series

$$\nu = 109750\left\{1\Big/\left(\tfrac{3}{2}\right)^2 - 1\Big/\left(\tfrac{n}{2}\right)^2\right\},$$

which includes the lines given by

$$\nu = \mathrm{K}\left\{1\Big/\left(\tfrac{3}{2}\right)^2 - 1/(n+1)^2\right\}$$

and by

$$\nu = \mathrm{K}\left\{1\Big/\left(\tfrac{3}{2}\right)^2 - 1\Big/\left(n+\tfrac{1}{2}\right)^2\right\},$$

and also a line which agrees in wave-length with the first member (λ6560·4) of the series

$$\nu = 109750\left\{1/(2)^2 - 1\Big/\left(\tfrac{n}{2}\right)^2\right\},$$

which includes the Pickering lines and the lines at 6560·4, 4859·5, 433·89, 4100·2, . . ., predicted by Bohr. It is also shown (ii) that the experimental values for the wave-lengths of the Pickering lines agree with the theoretical values calculated by Bohr within the limits of experimental error. These results point strongly to the conclusion that the series spectrum of hydrogen consists only of lines which are represented by the formula

$$\nu = 109750\,(1/n_1^2 - 1/n_2^2),$$

and that the series spectrum of He, in addition to the ordinary He lines, consists of all the lines which are represented by the formula

$$\nu = 109750\left\{1\Big/\left(\tfrac{n_1}{2}\right)^2 - 1\Big/\left(\tfrac{n_2}{2}\right)^2\right\}.$$

[See also Abs. 225 (1914).] A. W.

552. *Spectra of Hydrogen and Helium.* **T. R. Merton.** (Nature, 95. p. 65, March 18, 1915.)—Evans has described recently [see preceding Abs.] some interesting experiments on the "4686" and Pickering series, which were obtained from vacuum tubes containing helium, from which hydrogen was apparently completely eliminated. Stark has also observed the 4686 line in a vacuum tube showing no trace of the hydrogen lines. The experimental evidence of a helium origin of the lines in question would thus appear to be strong, and Fowler, from analogy with the enhanced line series of the alkaline earths, has also concluded that the lines are due to He. According to Bohr, who first suggested that the lines were due to He, the series in question owe their origin to the binding of an electron by a He atom, from which two electrons have been removed. Bohr's theory involves a modified value of Rydberg's constant for these lines, and Nicholson has pointed out that it

can be put to the test by an accurate measurement of the lines of the 4686 series, from which the value of the constant can be calculated. Although the spectroscopic evidence is in favour of He as the origin of the lines, it may be pointed out that this evidence is not conclusive. Although λ4686 does not appear in hydrogen in the absence of He, the same may be said of ultra-violet members of the Balmer series, which do not appear in vacuum tubes containing pure hydrogen, but which make their appearance when He is present. The difficulty of preparing vacuum tubes free from hydrogen is well known, and the fact that the ordinary hydrogen lines are absent from the spectrum cannot be taken as conclusive evidence that hydrogen is not present. In view of this fact, the author has conducted experiments to determine the relative mass of the atom from which the 4686 series originates, by measuring the limits of interference of the 4686 line and the lines of He and hydrogen. The circumstances which control the breadth of spectrum lines have been discussed by Rayleigh [Abs. 555 (1915)]. At low pressures the order of interference at which fringes are still visible is proportional to the square root of the atomic weight of the atom from which the radiation originates. A full account of the experiments will be published later, but the following may be stated as a preliminary result. A vacuum tube containing hydrogen and helium at low pressure was excited by an induction coil with capacity and a spark-gap in the circuit, the spectrum consisting of He, 4686, and the hydrogen lines. With an interference apparatus giving a suitable difference of path, moderately sharp ring systems can be obtained for all the He lines, whilst no trace of interference can be detected in the 4686 line or the hydrogen lines. Further observations are required to determine the exact limits of interference of the 4686 line and the hydrogen lines, but the results indicate that the mass of the atom from which the 4686 line originates is definitely smaller than that of the atoms concerned in the production of the ordinary helium spectrum. A. W.

553. *Comparison of Wave-length of the Neon Line* (λ6402) *with that of the Cadmium Line* (λ6438). **T. Takamine.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 9–12, Jan., 1915.)—Priest, using a method of reflection fringes, has previously determined the wave-lengths of 10 lines in the spectrum of neon, using the cadmium lines as standards [Abs. 384 (1911), 410 (1913)]. In the second of his papers, Priest states that the test of his results by an entirely different method is much desirable. Nagaoka has shown [Abs. 77 (1914)] that the method of coincidence of interference points, obtained by the combination of an echelon grating with a Fabry-Perot interferometer, is applicable to the accurate determination of wave-lengths. The present paper describes an application of this method for testing the result obtained by Priest. Taking the wave-length of the cadmium line in dry air at 15° C. and 760 mm. as 6438·4696 Å. units, the value found for the neon line from measurements made on 7 plates is 6402·2395 ± 0·00009. The value given by Priest is 6402·2392, the probable error relative to Ne λ5852 and Cd λ6438 being ± 0·0002 and ± 0·0003 respectively. A. W.

554. *Displacements in Spectral Lines.* **G. V. Morrow.** (Phil. Mag. 29. pp. 394–407, March, 1915.)—Certain zinc and titanium lines were examined both in the arc and the spark spectrum, with varying current strengths. The following are the chief results:—(1) The wave-lengths of lines in the spark spectrum of the pure metal are generally greater than those in the arc spectrum, but the displacement varies for different metals and for different lines

of metals. (2) The displacement increases with increasing current if this latter increases the vapour density. (3) The presence of atoms of another element appears to be of no importance. (4) Apparent displacements due to unsymmetrical broadening of lines can be caused by over-exposure of plates.
J. M.

555. *Widening of Spectrum Lines.* **Rayleigh.** (Phil. Mag. 29. pp. 274–284, Feb., 1915.)—Modern improvements in optical methods lend additional interest to an examination of the causes which interfere with the absolute homogeneity of spectrum lines. These may be considered under five heads, and it appears probable that the list is exhaustive:—(i) The translatory motion of the radiating particles in the line of sight, operating in accordance with Doppler's principle. (ii) A possible effect of the rotation of the particles. (iii) Disturbance depending on collision with other particles either of the same or of another kind. (iv) Gradual dying down of the luminous vibrations as energy is radiated away. (v) Complications arising from the multiplicity of sources in the line of sight. Thus, if the light from a flame be observed through a similar one, the increase of illumination near the centre of the spectrum line is not so great as towards the edges, in accordance with the principles laid down by Stewart and Kirchhoff; and the line is effectively widened. It will be seen that this cause of widening cannot act alone, but merely aggravates the effect of other causes. There is reason to think that in many cases, especially when vapours in a highly rarefied condition are excited electrically, the first cause is the more important. A discussion of the bearing of the different causes on the widening of spectrum lines is given, special reference being made to Schönrock's work on the subject [Abs. 1861 (1906)].
A. W.

556. *Anomalous Zeeman-effect in the Satellites of the Violet Line* (λ4359) *of Mercury.* **H. Nagaoka** and **T. Takamine.** (Phil. Mag. 29. pp. 241–252, Feb., 1915.)—The present paper is a continuation of the experiments [Abs. 867 (1914)] made on the satellites of the green and violet lines, λ5461 and λ4047 respectively. The study of the line λ4359 is especially interesting, as it is accompanied by more than ten satellites, whose displacements in magnetic fields are so diverse, that different cases of anomalies already noticed in the satellites of the two lines above mentioned are also found in those of λ4359. The method of observation was exactly the same as in the earlier work. The echelon grating was chiefly used, and some doubtful cases were also examined in the photograms of interference points, obtained either with the Lummer-Gehrcke plate or with the Fabry-Perot interferometer. Tables are given showing the results obtained, and the displacements of the *p*- and *s*-components are exhibited in diagrams. Typical photograms showing the lines in uniform and in heterogeneous fields are also reproduced. By using a very high resolving power, obtained by combining an echelon grating or a Lummer-Gehrcke plate with a sliding Fabry-Perot interferometer, and making the air-plate about 5 cm. thick, it was found that the principal line is really a group of three strong lines, the consecutive distance between them being about 6 m. Å. units. Fine structure has previously been found for the principal lines of λ5461 and λ4047. Details are given, with diagrams, for all the three lines.

The fact that these principal lines have fine structure will probably have an important bearing on the Zeeman-effect. In his theory of the Zeeman-effect, Voigt has shown that for a simple coupling with an electron, the change of wave-length for the p-component of a satellite takes place at first proportionally to the square of the field strength, and then according to a hyperbolic law. The behaviour of some of the satellites of the line λ4359 corresponds to this theory, and in addition several similar cases are met with in the s-components; this evidently calls for a new discussion of a system with another kind of coupling. A. W.

557. *New Type of Series in the Band Spectrum associated with Helium.* **A. Fowler.** (Roy. Soc., Proc. 91. pp. 208–216, March 1, 1915.)—The band spectrum associated with helium, as previously described by Curtis and Goldstein [Abs. 1947 and 1433 (1913)], includes bands with single heads and bands with double heads. A preliminary analysis of this spectrum has led to the following conclusions:—(i) The doublets do not follow the ordinary law of band spectra, but can be arranged in two series of the type hitherto exclusively associated with line spectra, and can be approximately represented by the usual formulæ involving the Rydberg constant. Nine bands of the main series and four of the fainter second series have been identified. (ii) The two series may be likened to the principal and diffuse series in the case of line spectra, but the usual relation between such series is not certainly indicated, and no equivalent of the sharp series has yet been traced. (iii) The doublet separations are not in accordance with those associated with line spectra; they diminish in passing along the series, but do not vanish at the limit. (iv) No regularity in the arrangement of the single bands has been recognised. A. W.

558. *Spectra of Ordinary Lead and Lead of Radio-active Origin.* **T. R. Merton.** (Roy. Soc., Proc. 91. pp. 198–201, March 1, 1915.)—The view that the spectra of isotopes are identical was first put to the test by Russell and Rossi and by Exner and Haschek, who examined the spectra of thorium and ionium preparations. The former, working with a mixture containing at least 10 % of ionium, found no lines which were not present in the spectrum of pure thoria. Soddy and Hyman found that the line λ4760·1 was stronger in ordinary lead than in lead obtained from thorite, but that the spectra in other respects appeared to be identical. Richards and Lembert [Abs. 1751 (1914)] also found the spectra to be identical. According to the views of Hicks, an atomic-weight term enters exactly into the separations of doublets and triplets in series spectra. No series have yet been found for lead, but Kayser and Runge have found that a group of 10 lines repeats itself three times with constant frequency-differences. It seems probable, however, that doublet or triplet series exist in the lead spectrum, and for the lines which fall into such series there should, according to the views of Hicks, be differences of wave-length in the two isotopes corresponding with the differences of atomic weight. In the present investigation the author has made a comparison of the wave-lengths of some of the most prominent lines in the spectrum of ordinary lead and of the lead in Joachimsthal pitchblende. The spectra were produced in the carbon arc, the carbons being cored with the pitchblende residues or with iron oxide containing a small proportion of ordinary lead. The residues contained a considerable quantity of iron, which served to give a comparison spectrum. A number of photographs were taken with the two spectra in juxtaposition, and the lead lines were found to be identical in the two spectra. With the object of setting some superior limit to any wave-length differences that might occur, the wave-lengths of the principal lines between λ3500 and λ4100 were independently measured in the two spectra. It was found that no differences greater than

0·03 Å. unit occur. On the assumption that the lead in the residues has an atomic weight about 0·5 unit less than ordinary lead, Nicholson calculates that if the separation of two series lines in a doublet were 50 Å. units at λ4000, then the separation due to the change of atomic weight should, according to Hicks's theory, be altered by about 0·3 Å. unit. If each of the lines were shifted by an equal amount, a change of wave-length of the order of 0·15 Å. unit in each line would result. No change of wave-length of this order can be observed. The line λ4058 was specially examined by photographing the ring systems produced by means of a Fabry and Perot étalon.

It is concluded that there is no difference of wave-length for this line so great as 0·003 Å. unit in the spectrum of ordinary lead and of the lead from pitchblende. A. W.

559. *Spectrum of Palladium.* **E. Paulson.** (Phil. Mag. 29. pp. 154–157, Jan., 1915.)—A list is given showing the spectrum lines of palladium arranged in groups showing constant difference of wave-number; the effect of applying a magnetic field to the light source is to show great differences in the separations, both for lines of the same group, or for different groups, thus discouraging the idea of any simple relation between the lines. There are a few outstanding regularities, and these are recorded in detail. C. P. B.

560. *Light Absorption and Fluorescence.* II. **E. C. C. Baly.** (Phil. Mag. 29. pp. 223–240, Feb., 1915.)—A continuation of the treatment of absorption and fluorescence on the basis of the energy-quantum theory [see Abs. 1258 (1914)]. A single quantum absorbed at a higher frequency must be given out as a whole number of quanta at a lower frequency. Hence, if ν_x is a characteristic infra-red frequency, the energy can only be absorbed at ν_1, ν_2, ν_3, etc., where ν_1, ν_2, ν_3, etc., are successive multiples of ν_x. In other words, these higher frequencies have a constant difference, ν_x, equal to a characteristic infra-red frequency. Further, the author has extended Bjerrum's conception [Abs. 1946 (1913)] of the composition of short-wave infra-red bands to the visible and ultra-violet regions.

A characteristic frequency, ν, within the molecule, gives rise to three bands, $\nu - \nu_1$, ν, $\nu + \nu_r$, in general, from the imposition of the molecular rational frequency ν_r; where $\nu_r = hn/2\pi^2 I$, I being the moment of inertia, and h Planck's constant. Applying this to the ultra-violet, a pair of bands $\nu \pm \nu_x$, should be associated with an ultra-violet frequency ν, ν_x being a short-wave infra-red frequency. The theory is then rigidly applied to the absorption, fluorescent and phosphorescent spectra of benzene, toluene, *o*-, *m*-, *p*-xylene, and naphthalene. The results for benzene are typical, and are summarised:—

	$\nu\left(\frac{1}{\text{A.U.}}\right)$	ν_x	Infra-red frequencies observed by Coblentz.
Vapour (Absorption—Hartley) ...	4055	17 values	15 of these values
(Fluorescence—Dickson)	3645	3 ,,	All values
(Phosphorescence—v. Kowalski)	2420	10 ,,	6 ,,

Considering the difficulty of accurately measuring weak infra-red bands, it is probable that some of the theoretically indicated bands have been unobserved by Coblentz. In all cases more infra-red bands are indicated than have been observed, but every infra-red band so far measured is included in the calculated bands. Further, the central ultra-violet frequency, ν, of one compound differs in the absorption, fluorescent and phosphorescent spectra, but in each case is a multiple of the same characteristic infra-red frequency. This is well illustrated by *p*-xylene :—

Central Frequency of Spectrum.		Central Frequency of Spectrum.	
Kathodo-luminescence...	8×257	Fluorescence..............	14×258
Phosphorescence	10×256	Absorption..................	15×258

The values of the other fundamental frequencies are: Benzene and toluene, 405; naphthalene, 302; *o*-xylene, 301; *m*-xylene, 297. C. S. G.

561. *X-ray Fluorescence and the Quantum Theory.* **C. G. Barkla.** (Nature, 95. p. 7, March 4, 1915.)—A theory of X-ray fluorescence, based on experimental conclusions given in a previous paper [see Abs. 563 (1915)] is indicated. From his experiments the author states that the ejection from an atom of an electron associated with a fluorescent X-radiation of frequency n necessitates an absorption of energy greater than the kinetic energy carried away by the electron by the energy (hn) of one quantum of radiation of frequency n. Thus—Total absorption per electron emitted $= \frac{1}{2}mv^2 + hn$ approx.—*i.e.* the energy required to separate the electron (a K electron, say) from the parent atom, is approximately equal to the energy of a quantum of fluorescent radiation of series K associated with that electron. To satisfy experimental facts more accurately, however, this simple relation is modified slightly as follows:—Total absorption per electron emitted $= \frac{1}{2}mv^2 + hn_K + hn_L$, where n_K and n_L are the frequencies of the K and L fluorescent radiations respectively. The max. value of the term (hn_L) is only about 7% of the whole. The relation indicates that *possibly* the energy required to free a K electron is equal to the sum of the energies of quanta of K, L, and any other fluorescent radiation of lower series M, N, etc. Again, the energy of a quantum of K radiation is that required to displace a K electron into the position of an L electron, and so on. It becomes obvious, from considerations of this nature, when and why an electron falls into an inner ring: it is simply subsequent to and due to the removal of an inner-ring electron. We should expect from this that L radiation would be associated with the emission of K electrons as well as with L electrons. Search for such a radiation is at present being made. Direct evidence has been obtained that the energy of a quantum is the energy absorbed in removing the corresponding electron from its normal orbit; it is the energy afterwards liberated, presumably when the electron returns. Experiments are now in progress to determine if X-ray fluorescence—arising from the vibration of inner-ring electrons—can be appreciably delayed by retarding the return of the ejected electrons from outside the atom. A. B. W.

562. *Relation between Certain X-ray Wave-lengths and their Absorption Coefficients.* **W. H. Bragg.** (Phil. Mag. 29. pp. 407–412, March, 1915.)—Barkla has shown that, in general, X-rays characteristic of any substance are strongly absorbed by substances of smaller atomic weight as compared with substances of greater atomic weight. It is now shown that this phenomenon can be more definitely expressed in terms of wave-length. The following X-ray spectra are produced in illustration:—(1) Rhodium in calcite (111), second order; (2) Palladium in diamond (111), first and third orders; (3) Silver

in diamond (111), first and third orders. In determining these spectra, readings were taken every two minutes of arc, and every minute in important regions. The spectrum of Rh contains *four* lines, the two of longest wavelength constituting the doublet previously examined [Abs. 1840 (1914)]; these latter are spoken of separately as a_1 and a_2. The third is denoted the β-line, whilst the fourth, which has not been previously observed, is marked γ. The spectra of the three metals Rh, Pd, and Ag are remarkably similar in character. In the following table the wave-lengths of the various lines observed are given in Ångström units.

TABLE I.

	Ag.	Pd.	Rh.
a_1	0·562	0·589	0·619
a_2	0·557	0·583	0·614
β	0·495	0·516	0·545
γ	0·488	0·503	0·534

In illustration of the remarkably strong absorption in palladium of the β-ray of silver (0·495 Å.U., see table above) the values in Table II. are given.

TABLE II.

X-ray.	Log of Wave-length in Å.U.	Log of Atomic Absorption Coefficient × 10^{22}.	
		Pd.	Ag.
Ag-β	$\bar{1}$·6946	2·064	1·260
Pd-β	$\bar{1}$·7126	1·301	1·342
Rh-β	$\bar{1}$·7364	1·350	1·394
Ag-a	$\bar{1}$·7459	1·377	1·403
Pd-a	$\bar{1}$·7657	1·452	1·477
Rh-a	$\bar{1}$·7882	1·498	1·545

On plotting these values it is seen that all the points representing the way in which the absorption of the different rays by Ag depends on the wave-length lie on a straight line. Nothing remarkable is observed in the "silver" curve, the points for the Ag wave-lengths lying on a straight line passing through the points for the wave-lengths of Pd and Rh. On examining the Pd curve everything appears the same, except that *the short Ag wave 0·495 is highly absorbed*, and no doubt excites Pd rays. This cannot be explained on the grounds that it is shorter than some of the Pd rays, because the Pd wave 0·516 cannot excite Ag waves of greater length.

The author suggests that the most probable condition would seem that the exciting wave must be shorter than all the characteristic waves of the substance in which it excites those waves; it is observed that the Ag β-wave is just shorter than the γ-wave of Pd. Again, it may be that the characteristic rays of a substance form a system which can only be excited as a whole.

A. B. W.

563. *Problems of Radiation.* **C. G. Barkla.** (Nature, 94. pp. 671–672, Feb. 18, 1915.)—Barkla and Sadler [Abs. 1049 (1909) and Phil. Mag. 17. p. 789] have shown that when a beam of primary X-radiation falls on an element, a definite portion of the energy absorbed can be associated with the emission of a particular fluorescent radiation. The element thus exposed emits also a corpuscular radiation, a portion of which is definitely connected with each fluorescent X-radiation. From measurements of these associated quantities the author draws the following broad conclusions :—(1) The number of quanta of fluorescent X-radiation emitted is equal to the number of high-speed electrons in the corpuscular radiation (*i.e.* the associated corpuscular radiation). (2) The total energy of the corpuscular and fluorescent radiations is equal to that of the primary beam absorbed.

These conclusions are discussed in more detail in the paper, curves connecting "energy of secondary radiation" with "wave-length of primary radiation" being given. It is shown that when the wave-length (μ_1) of the primary radiation is just less than the wave-length (μ_2) of the characteristic radiation the energy is equally divided between the corpuscular and fluorescent X-radiations. As μ_1 diminishes a greater proportion of the energy goes into the corpuscular radiation, and less into the fluorescent, until for very short wave-lengths all the energy is taken up by the corpuscular radiation. This simple theory is borne out by experiments with the element bromine. Deviations—real or apparent—from this simple explanation are at present under investigation. The following are other important conclusions based on the above theory :—(1) The absorption by an atom is not necessarily in *whole quanta* of the primary radiation; evidence has been obtained of absorption of primary radiation in quantities of any magnitude between one and two quanta of the primary radiation, or even in fractions of one quantum. (2) The transformation of primary radiation into fluorescent radiation is accompanied by little, if any, loss of energy within the atom. (3) The energies of X-radiations differing widely in penetrating power are approximately proportional to their total ionising powers. A. B. W.

564. *Characteristic Boundary Phenomena with Röntgen Rays.* II. **J. Laub.** (Phys. Zeitschr. 15. pp. 622–624, June 15, 1914.)—A further account of the investigation referred to in Abs. 1424 (1914). A parallel beam of X-rays from a hard bulb with Pt antikathode grazed the boundary of a round hole in a lead screen (diam. 8 cm.) for 85 minutes. On the photographic plate placed to receive the rays behind the screen was found a sharply bounded, evenly darkened ring, the rest of the plate being very weakly but also evenly darkened. When the bulb was so placed that the rays fell obliquely on the boundary, after an exposure of 85 mins. there was seen on the photographic plate a circle which was produced by the rays passing directly through the circular hole. This was surrounded by a small dark ring, and this again was surrounded by another, broader, uniformly darkened ring, but of lesser intensity. When a Zn sheet 0·6 mm. thick was brought immediately behind the lead screen leaving a very small segment of the circular hole in the latter uncovered, and the rays were passed through the screen for 85 mins., there was found on the photographic plate a slit caused by the direct rays from the bulb, separated from the circle produced by the rays passing through the hole in the lead screen and the zinc sheet covering it by a minimum intensity band, and on the other side of the slit more lines and bands were to be seen.

These results are explained as follows: The boundaries possess an anisotropic structure and cause a diffraction of the Röntgen rays. The lines obtained have their origin in the rays which are diffracted at the straight edge of the Zn boundary, and the different lines are diffraction images of different orders. Diffraction also occurred at the lead boundary under certain conditions, so that the total effect of the diffraction of the boundaries is to produce diffraction images of the whole slit. The author points out that the phenomena observed can play a very great part in spectroscopic measurements of X-rays. The slits used by different investigators can themselves furnish lines on the photographic plate which are not caused by the diffraction of the Röntgen rays by the crystal. E. A. O.

565. *Characteristic Boundary Phenomena with Röntgen Rays.* III. **J. Laub.** (Phys. Zeitschr. 15. pp. 665–667, July 1, 1914.)—Diffraction images were obtained by using Pb, Cu, C, and S boundaries [see preceding Abs.]. The different rings are considered as diffraction images of different orders. In the case of Pb, when a sheet of glass 2 mm. to 3 mm. thick was placed behind the screen, the rings could hardly be seen, pointing to the fact that only the softer rays were diffracted by the Pb boundary. The author points out that the extraordinary anisotropy at the boundaries may be accounted for by (1) the presence of microcrystals in the body which are originally quite irregularly arranged, but obtain in the course of the mechanical working of the boundary (cutting, etc.) an orientation in the direction of the boundary; (2) forces at the boundary which cause an anisotropic arrangement of the molecules; (3) the shifting of the molecules caused by the irradiation of the boundary. The results obtained by various investigators by passing rays through metal sheets seem to point to (1) for their explanation, but those now obtained with C and S seem to require an explanation by either (2) or (3). It is important to know whether it is necessary for the existence of the boundary effect to suppose that microcrystals must be present in the irradiated body before the Röntgen rays are diffracted at the boundary.

A further curious phenomenon observed is the following. After passing the rays through the screen for a long time there is observed on the plate outside the circle (caused by the exposure of the plate to the direct rays) and the diffraction images, bright specks of irregular form on an otherwise uniformly darkened background. There are also bright specks in the circle caused by the primary rays as if at these particular places the rays had no effect on the photographic plate. The number and form of the specks vary much with the angle of incidence of the rays and the distance of the photographic plate from the irradiated body. The author has not succeeded in obtaining the same result on two consecutive photographs. E. A. O.

566. *Characteristic Boundary Phenomena with Röntgen Rays.* IV. **J. Laub.** (Phys. Zeitschr. 15. pp. 730–732, Aug. 1, 1914.)—[See two preceding abstracts and Abs. 1424 (1914).] A hole of irregular shape was cut in a lead screen and a parallel beam of rays passed through it. It was noticed that the diffraction rings found on the photographic plate round the direct image of the hole were of exactly the same shape as that of the hole itself. The hardness of the rays producing the different rings decreased as the distance of the ring from the direct image increased. Similar diffraction phenomena were observed with glass as a boundary. Hence it is possible to produce an image of the contours of bodies by diffraction of Röntgen rays and also to diffract the rays at the boundaries of amorphous bodies. E. A. O.

567. *Dispersion of Röntgen Radiation at a Lead Boundary.* **J. Laub.** (Phys. Zeitschr. 15. pp. 732–733, Aug. 1, 1914.)—[Further to the three preceding abstracts and Abs. 1424 (1914).] A parallel beam of rays was passed through a slit (0·3 mm. wide) between two pieces of lead 15 mm. thick. The photograph, after an exposure of from 1 to 6 hours, showed the direct image of the slit bounded on each side by sharp lines and bands. These were symmetrical on both sides of the slit, and in one case as many as 5 lines were observed. The lines are explained as being due to the characteristic rays from the Pt antikathode of the bulb. E. A. O.

568. *Experiments on the Active Deposit of Radium.* **E. M. Wellisch.** (Am. J. Sci. 38. pp. 283–304, Oct., 1914. Phil. Mag. 28. pp. 417–439, Oct., 1914.)—In a previous paper [Abs. 249 (1914)] it was shown that when RaEm is mixed with any gas there is a definite limit to the fraction of the active deposit which settles on the kathode in an electric field. Thus the values were 89·2 % for air and hydrogen, 80·7 % for CO_2 and 10 % for ethyl ether. The physical interpretation of this limiting value is that it represents the fraction of the total number of deposit particles which possess a positive charge at the end of the recoil path, before either columnar or volume recombination have had a chance to become operative. The small value of the limit in the case of ethyl ether was ascribed to the large density of ionisation produced by the deposit particle during its motion of recoil. It had previously been shown that with air or hydrogen the deposit particles are either positively charged or neutral; thus it became of interest to ascertain whether negatively charged particles were present when the emanation was mixed with ether. This was the immediate purpose of the present investigation, but the field has been greatly extended. The apparatus and method of experiment have been previously described [*loc. cit.*]. The following table shows that the application of either a positive or negative potential is without any decided effect on the distribution of the active deposit:—

Pressure, mm.	Potential, volts.	Percentage Deposit on Central Rod.
82	+ 750	9·1
87	− 750	9·2
82	− 160	9·6
88	− 20	9·2
89	+ 20	10·0
89	− 160	9·2
93	+ 4	10·4
80	− 2	10·4
87	0	10·3

The fraction of the total activity which should appear on the rod by diffusion only (central rod and case being earthed) has been calculated from theoretical considerations. Thus for a rod, radius $a = 1·0915$ cm. and cylinder, radius $b = 2·9$ cm., this fraction $= 0·144$, which is greater than the observed value 0·105, but several corrections are indicated which would bring these values into closer agreement. The results in the above table indicate that, very approximately, all the deposit particles are uncharged and reach the electrodes by diffusion. A slight correction has to be made for the limiting values of the kathode deposit in air, H_2, and CO_2 given in the previous paper.

When relatively small amounts of emanation were employed the "gas activity" was found to be a definite fraction of the total activity. With larger amounts of emanation, however, large variations were observed which rendered a systematic investigation necessary. The results of this investigation are readily explained on the view that there are charged *aggregates* of active deposit. These aggregates diffuse very slowly, and therefore accumulate in the gas, so that in the steady state there is a large amount of "gas-activity." There is abundant evidence that the aggregates owe their charge to the ions present in the gas: this point is further emphasised by passing a beam of X-rays through the gas, when both positive and negative gas activity are considerably increased as a result of the extra ionisation. The general observation is made that the active-deposit atoms in the gas charge up, both positively and negatively, in appreciable numbers when the density of ionisation exceeds a certain amount; the atoms thus charged act as nuclei of condensation and build up aggregates of active particles when these are present in sufficient quantity. The diffusion of the active deposit is considered in detail mathematically, whence the author deduces that the number of active-deposit particles in the gas in the steady state is $G = 108{\cdot}1\ \pi q/D$ for a cylinder of length 14 cm. and radius 2·9 cm. In this equation D is the coefficient of diffusion, and q the number of active deposit particles produced per cm.^{3} from the emanation. If Q be the total number of particles produced per min. in the gas contained in the cylinder, $D = 0{\cdot}0146\ Q/G$. Thus, to determine D it is necessary to measure the ionisation currents resulting from Q and G under similar conditions. The value $D = 0{\cdot}0445$ cm.^{2} sec.$^{-1}$, deduced from the results of experiments of this nature, is given as the most probable value for the coefficient of diffusion of uncharged atoms of radium active deposit in dry air at ordinary room temperatures and pressures.

The author next proceeds to discuss experiments of a similar character by G. Eckmann (Jahrb. d. Radio-akt., 1912], and, using the experimental value of Q/G determined by this investigation, obtains a value 0·0443 for D, in excellent agreement with the result given above. A. B. W.

569. *Tracks of α-Particles in Photographic Films.* **S. Kinoshita** and **H. Ikeuti.** (Phil. Mag. 29. pp. 420–425, March, 1915.)—Kinoshita [see Abs. 922 (1910)] has shown that each α-particle striking a grain of silver halide in a sensitive film renders that grain developable. This observation has been employed by several investigators to demonstrate the tracks of α-particles in a photographic film. Recently Walmsley and Makower [Abs. 181 (1915)] succeeded in obtaining photomicrographs in which the rectilinear paths of α-particles, both undeflected and scattered, were beautifully exhibited. The authors, who have been engaged on the same investigation, show in the present paper an interesting series of photographs of a similar nature. A sewing-needle, carrying at its point a minute trace of radium active deposit, is employed as a source of α-rays. After the active needle has been in contact with a photographic plate for a short time, the plate is developed and a fine spot becomes visible to the naked eye. On examining the plate under a microscope this spot is seen to consist of a multitude of radial trails of silver grains around a circular dark nucleus. Haloes are also observed, and are shown to be produced by a process similar to that of the pleochroic halo seen in a mineral such as biotite, and investigated in detail by Joly. Microphotographs showing the haloes at different stages of formation are reproduced. The difference in radii between a halo and the circular nucleus inside it was found to be the same, 0·054 mm., for all cases; this value probably represents the range of the α-particle, emitted from RaC, in the film.

It is suggested that the grains spreading out over a wide region in a less definite manner are to be attributed to β-particles. Experiments of the above character were also made using a powerful magnetic field to deflect the α-particles. Working with fields up to 10,000 gauss no indication of curving of track was observed—of course such a slight curvature would not easily be recognised, as the length of path in the film is only 0·054 mm. No definite evidence has been obtained showing large-angle scattering of α-particles by the silver grains, further investigation being necessary to settle the question as to whether some of the tracks are actually due to single α-particles or to two particles passing through the film in different directions. A. B. W.

570. *Condensation of Thorium and Radium Emanations.* **A. Fleck.** (Phil. Mag. 29. pp. 337–362, March, 1915.)—As a result of their first experiments on this subject, Rutherford and Soddy [see Abs. 95 (1904)] found that whilst radium emanation condensed at − 155° C., thorium emanation was condensed over a range of temperature varying from − 120° C. to − 155° C. The three radio-active emanations are isotopic, occupying the same place in the periodic table, but as they belong to the family of chemical inert gases they are, of course, chemically indistinguishable. The present experiments have been undertaken with a view to determine whether or not the Th and Ra emanations could be separated from one another by condensation.

(A) *Experiments at Atmospheric Pressure.*—In the first series of experiments the methods used were the same in principle as those employed by Rutherford and Soddy, in which the emanation was mixed with air at atmospheric pressure. (1) *Thorium Emanation Alone.*—Curves are given showing the relation between the fraction condensed and the temperature, whence it is evident that thorium emanation is gradually condensed until a temperature of − 154° C. is reached, when it is completely condensed. (2) *Mixed Thorium and Radium Emanations.*—Of course, the only possible way to test whether the two emanations have exactly the same condensation point is to mix them thoroughly before cooling to low temperatures. In this case it is shown that the two condensation curves are quite distinct, ThEm being more easily condensed than RaEm—the *form* of the two curves is, however, the same. It is shown that the exact temperature at which the emanations condense depends to a large extent on physical conditions prevailing during the experiment, presence of water-vapour having a marked effect. The above results are not proof that the emanations have dissimilar properties of condensation, since allowances must be made for the vapour pressures of the condensed emanations.

(B) *Experiments at Low Pressures.*—To avoid sweeping away the vapour phase (especially in the case of RaEm) by the air current used in (A) experiments were made on the emanations in closed tubes. The important point of the method was to have the emanations enclosed in a tube at very low pressure, and to assume that a quantity of gas would diffuse throughout the tube instantaneously. (1) *Radium Emanation Alone.*—The results of these experiments show (*a*) that different tubes, in general, have different condensation curves, (*b*) that as the concentration of the emanation diminishes it becomes easier to condense, and (*c*) that there exist *two* maximum points, one at −161° C. and the other at − 72°5 C. Many peculiarities in the process of condensation are observed, some of these being explained on the assumption that gas is liberated from the walls of the tube; the observations show the great difficulty attaching to experiments of this character. It is suggested that the presence of two maxima is dependent on the water-vapour present in the tube. (2) *Thorium Emanation Alone.*—The curves shown in this case are similar to the curve obtained by Rutherford and Soddy for ThEm mixed with air at atmospheric pressure. The greater part of the emanation is condensed between —165° C. and —170° C. (3) *Mixed Thorium and Radium Emanations.*—A table is given showing the fractions condensed at different temperatures. It is evident from this table that at any temperature the fraction of RaEm condensed is greater than the corresponding fraction of ThEm. From this observation it might seem obvious that radium emanation is more easily condensed than thorium emanation. When fully examined, however, the points separate themselves into two groups, each of which lies on a curve. The curves of one set are roughly parallel to, but from 7° to 10° lower than, those of the other set.

The theory of these experiments is supplied by Soddy, who considers that the observed results may be due to the rapid disintegration of ThEm, and the apparent separation effected by condensation may be a time separation of isotopes differing in period, rather than due to a true difference of volatility.

In none of the experiments with ThEm nor with mixed emanations has any trace been found of the maxima observed in the case of RaEm alone. Various possible explanations of this phenomenon are advanced, but no definite conclusion is reached. A. B. W.

571. *Radium Emanation in Petroleum.* **K. Fuji.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 13–14, Jan., 1915.)—Measurements have been made of the emanation-content of petroleum obtained from the Nisiyama Oilfield in Etigo. The apparatus used and the methods employed in the determinations were the same as those used by Ikeuti [Abs. 686 (1914)] in his determination of the radio-activity of hot springs. Samples of petroleum and gases which had been taken at different levels were examined. The amount of emanation in the petroleum varied from 166×10^{-12} to 114×10^{-12} curie per litre, whilst in the gas 35×10^{-12} was the average value obtained. The solubility of RaEm in petroleum was separately determined. Although this quantity varied considerably with different samples of petroleum, it was always found to be appreciably greater than in water. As will be seen from the above results the emanation, contrary to the case of hot springs, is contained more in liquid than in gas. A. B. W.

572. *Radio-activity of Mineral Springs.* **D. Isitani.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 15–35, Jan., 1915.)—This paper gives a detailed report of the determination of the radio-activity of a large number of mineral springs in the Miyagi Prefecture. In all, the waters of 30 different spas have been examined and the results tabulated for purposes of comparison. The characteristics of each spring are discussed in relation to the emanation-content. A. B. W.

HEAT.

573. *The Leduc-effect in some Metals and Alloys.* **A[lpheus] W. Smith and A[lva] W. Smith.** (Phys. Rev. 5. pp. 35–42, Jan., 1915.)—If a metal plate of width w having a longitudinal flow of heat is placed in a magnetic field H, perpendicular to the plane of the plate, there will be a transverse difference of temperature $\Delta\theta$ for a given longitudinal temperature gradient $\partial T/\partial x$, such that $\Delta\theta = {}_kT_k w H \partial T/\partial x$, where ${}_kT_k$ is the coefficient of the Leduc-effect. This coefficient was determined for Ni, Co, nichrome, electrolytic iron, Mo, W, Cd, Zn, and Sb in a field of about 11,000 gauss and at a temperature of about 60° C. The coefficients for Ni and Mo are negative. In the magnetic metals the transverse difference of temperature set up is proportional to the intensity of magnetisation of the plate, and not to the intensity of the field. In antimony the Leduc coefficient is independent of the intensity of the field. [See also Abs. 937 (1911).] G. E. A.

574. *Specific Heats of Liquids and Vapours at Constant Pressure and at Constant Volume.* **S. Pagliani.** (N. Cimento, 8. pp. 157–188, Sept., 1914.)—The author compares his earlier results (1883–1890), recalculated on the basis of experimental data concerning specific heats published since 1884, with those obtained by Tyrer [see Abs. 378 (1915)]. Within the limits of temperature employed the specific heats at constant volume for most of the 16 liquids for which data are available increase with rise of temperature, but water, carbon tetrachloride above 30°, and carbon disulphide above 10° are exceptions to this rule; Tyrer's statement, that the extent of this increase rises with the number of atoms in the molecule of the liquid, is not verified. For water, just as for the liquids examined by Tyrer, the specific heat at constant volume for the liquid is greater than that for the vapour at the same temperature. Although the specific heat of water, unlike those of the other liquids, decreases with rise of temperature, that for water-vapour exhibits a diminution similar to those for the other vapours, the differences being generally very small. As a rule, the difference between the two specific heats, which is equivalent to the work of thermal expansion, is greater for a liquid than for its vapour at the same temperature, yet for water and for methyl alcohol the value of this difference for the liquid coincides with that for the vapour at a certain temperature; at lower (or higher) temperatures the difference is less (or greater) for the liquid than for the vapour. These results seem to corroborate the view that the energy absorbed during the expansion of a liquid is mainly employed, not in overcoming the external pressure, but in effecting internal work necessitated by the intermolecular attraction or in increasing the molecular energy.

Tyrer's general relation, that the difference between the two specific heats increases continuously with rise of temperature, does not hold for certain liquids; thus, for carbon tetrachloride, it is valid only above 20°, and for chlorobenzene only above 50°, whilst with toluene, xylene, and cymene this difference varies in the opposite sense. Conclusions in support of, or against, the de Heen hypothesis cannot therefore be drawn from these variations.

Further, for all normal liquids, the value of the expression, $(c_p - c_v)v^2/(dv/dt)$, is not constant but variable, so that here again Tyrer's conclusions are invalid. Also, the product of the molecular weight and the factor $(c_p - c_v)$ is not constant for normal liquids at one and the same temperature, although the values of this product for members of any one chemical series are of similar orders of magnitude. The expression $l(dv/dt)/v(c_p - c_v) = 1$ [Tyrer, *loc. cit.*] is not of general application. Neither the relation deduced by Tyrer, who found that the ratio between the two specific heats remains constant for all liquids, nor that of Lussana [Abs. 1689 (1914)], who stated that this ratio always diminishes with rise of temperature, is confirmed; increases of the ratio are indeed observed for water between 0° and 100°, ethyl alcohol above 20°, amyl alcohol above 40°, chloroform above 20°, carbon tetrachloride above 30°, and carbon disulphide between 0° and 40°. In general, although not invariably, this ratio decreases with increase in the molecular weight in a homologous series. Increase with the density is not universally the case, since, within certain ranges of temperature, increase of the ratio with rise of temperature occurs with such liquids as water, benzene, ethyl and isoamyl alcohols, chloroform, carbon tetrachloride, and carbon disulphide. Tyrer's results furnish no demonstration of the Dupré-Amagat equation; his expression, $\beta = T(dv/dt)v/C_1$, exhibits mere analogy of form to this equation and is not verified by experiment. T. H. P.

575. *Electrically Heated Full Radiator.* **H. B. Keene.** (Roy. Soc., Proc. 91. pp. 190–197, March 1, 1915.)—In a previous paper by the author [Abs. 688 (1913)] the value of the radiation constant of the Stefan-Boltzmann law was obtained, using an apparatus which fulfilled the condition of a full receiver. The present paper describes an electrically heated, high-temperature full radiator. The radiator consists of a bottle-shaped crucible of alumina with a cylindrical body 8 in. in diam., and with conical ends and circular aperture. The crucible was wound with Pt strip for electrical heating. In order to prevent breakages of the strip on cooling it was "crimped" between two cog-wheels and separated from the crucible by a pliable mica bed. Dental cements at first used for keeping the strip in place gave trouble owing to electrolysis, so pure aluminium oxide was used instead and proved quite satisfactory. A special mica framework was used for keeping the strip in position on the conical parts of the crucible. A side hole was provided for the introduction of a standardised thermo-couple for measurements of the temperature; the temperatures were observed by means of the deflection of a calibrated moving-coil galvanometer, which method is of sufficient accuracy for the purpose of obtaining uniformity, since an absolute value of the temperature is not required. The apparatus was designed to operate at about 1100° C., and measurements of the temperature at various points in the interior of the crucible showed a variation of not more than 3 deg. C., the temperature in this series of readings rising slightly. There is no satisfactory means of determining the diffusing power of a sample of the alumina at the temperature of the radiator owing to the difficulty of obtaining the actual temperature of the radiating surface of an exposed sample. It is highly probable that a porous clay is an exceedingly good radiator on account of the pores providing a surface of minute full radiators. Such was the surface of the crucible. As a further precaution the surface was covered with a dull black coating, which would withstand a temperature of 1100° C. Barlow has shown that the radiation passing through a circular aperture of area a in a spherical uniform temperature cavity of cross-section A departs

from the full radiation at that temperature by approximately aR/A per cent., where R is the percentage of the radiation diffusely reflected by the material. If we assume that the black alumina surface diffusely reflects as much as 5 %, then the radiation from the aperture of the apparatus described departs from the full radiation at that temperature by only about 0·2 %. The crucible was supported by means of two blocks of alumina which rested in the collars of the two circular end castings. These castings were rigidly attached to each other by means of a steel cylindrical jacket, the intervening spaces being filled in with kieselguhr. A. W.

576. *Isothermals of Diatomic Substances and their Binary Mixtures.* XV. *Vapour Pressures of Oxygen and Critical Points of Oxygen and Nitrogen.* **H. K. Onnes, C. Dorsman, and G. Holst.** (K. Akad. Amsterdam, Proc. 17. pp. 950–958, Feb. 27, 1915. Communication No. 145*b* from the Phys. Lab., Leiden.)—By means of the apparatus previously described [Crommelin, Leiden Comm. No. 115] the vapour pressures of oxygen at 12 different temperatures ranging from 118·18° to 154·19° K. and the critical points of oxygen and nitrogen have been determined. In order to determine the critical constants, small portions of isothermals were studied in the neighbourhood of the critical point. Starting from a temperature below the critical temperature and compressing a suitable volume by small amounts, a condition can be found which, when next compressed, gives rise to condensation; if the starting-point is above the critical temperature, condensation cannot occur. These observations were repeated within narrower limits of pressure, the temperatures ascending by about 0·05°. The critical point was ultimately taken as that where, on a small expansion, the meniscus appeared half-way up the tube, and where, as the temperature re-established itself, it disappeared at the same level; by this procedure the critical temperature may easily be determined to within 0·05°. The critical opalescence was not observed, and, if it exists, must be very slight.

The critical temperature and pressure are: for oxygen, $T_k = 154{\cdot}25°$ K. and $p_k = 49{\cdot}713$ atmos., and for nitrogen, $T_k = 125{\cdot}96°$ K. and $p_k = 33{\cdot}490$ atmos. Using the critical values obtained for oxygen, the critical coefficient, $K_{4d} = RT_k/p_k v_{kd}$—where v_{kd} is the critical volume derived from the diameter —is now found to be 3·419, instead of 3·346 as deduced by Mathias and Onnes from incorrect data given in the literature. The new value is no longer abnormally small in comparison with that of normal substances of higher critical temperatures, and is nearly the same as that for argon, 3·424.

T. H. P.

577. *Isothermals of Diatomic Substances and their Binary Mixtures.* XVI. *Vapour Pressures of Nitrogen between the Critical Point and the Boiling-point.* **C. A. Crommelin.** (K. Akad. Amsterdam, Proc. 17. pp. 959–962, Feb. 27, 1915. Communication No. 145*d* from the Phys. Lab., Leiden.)—The results here given have been obtained with the apparatus previously employed, but the dilatometer used was not provided with a stirrer, and the values obtained for the vapour pressures of nitrogen seem to be somewhat less accurate than those for oxygen. The vapour pressure varies from 30·364 atmos. at —148·85° to 1·4727 atmos. at —191·88°, and comparison is made with the calculated values derived from a formula of the type $\log p = a + b/T + c/T^2 + d/T^3$, T being the absolute temperature and the coefficients having the values $a = +5{\cdot}76381$, $b = -853{\cdot}522$, $c = +54372{\cdot}3$ and $d = -1783500$ which satisfy the critical constants, $p_k = 33{\cdot}49$ atmos. and $T_k = 125{\cdot}96°$ K

The agreement between the two series of values is not very close, partly because the critical point falls slightly outside the extrapolated vapour pressure curve. T. H. P.

578. *Rectilinear Diameter of Nitrogen.* **E. Mathias, H. K. Onnes,** and **C. A. Crommelin.** (K. Akad. Amsterdam, Proc. 17. pp. 953–959, Feb. 27, 1915. Communication No. 145*c* from the Phys. Lab., Leiden. Comptes Rendus, 160. pp. 237–239, Feb. 15, 1915.)—The authors are pursuing further the work begun with oxygen [Abs. 1582 (1910)] and continued with argon [Abs. 1171 (1913)]. The present investigations on nitrogen have been made with a slightly modified form of the apparatus previously used. No isotherms for nitrogen at low temperatures are available, and it is assumed that the behaviour of this substance is similar to that of ether and isopentane. For the calculation of the capillary corrections for the liquid nitrogen, Baly and Donnan's observations [Abs. 4 (1908)] are employed. The deviations of the observed from the calculated rectilinear diameter are found to be systematic and, in the neighbourhood of the critical point, fairly considerable, and it seems probable that these large deviations are connected with the divergence of the critical point from the extrapolated vapour-pressure curve. The coefficient of inclination of the diameter is —0·0019577, which is considerably less than those for argon, —0·0026235, and oxygen, —0·002265. The "undisturbed" critical density derived from the diameter, and taking the critical temperature to be —147·13°, is 0·31096. The critical coefficient, 3·421, is comparatively small, as was to be expected from the simple molecular structure of nitrogen; its deviation from the theoretical value 8/3, is in the same direction and to a similar degree as with argon (3·424) and oxygen (3·419). The liquid densities found for the low temperatures differ from those given by Baly and Donnan (*loc. cit.*) by amounts of the order of 1 %.

T. H. P.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

579. *Electricity in the Atom from the Contemporary Point of View.* **V. K. Lebedinski.** (Electritchestvo, 36. No. 1. pp. 1–8, Jan., 1915.)—The author reviews the facts which have gradually led up to the electronic theory. A large part of the paper is made up of researches which have become already classical. It is claimed that in Russia A. I. Sadovski, in the year 1889, showed by Maxwell's theory that if a polarised ray is transformed within a crystalline lamina to a circularly polarised ray, then the lamina ought to experience a certain turning movement; and the author goes on to say that under the conditions of the experiment that moment was found to be extremely small —as small as it was possible to observe. This exposition of the rapid dissipation of the energy of light in producing a direct mechanical effect was printed in Russian, but did not attract much attention in the local scientific world owing to lack of confidence in the opinions of the people composing it. It is held that C. I. Pokrovski, Shaposhnikoff, and P. C. Epstein, in 1914, have contributed to the strengthening of the foundation of the electronic theory as derived from electromagnetic effects, and have aided in rendering less obscure the things arising out of this theory. The Moscow physicist, Shaposhnikoff, in reviewing the theory of M. Abraham, of Milan, proposed to rid it of unnecessary refinement, and to put the question simply in the following way:—Circularly polarised light is that in which electrical forces, perpendicular to the ray, rotate around it; upon the penetration of such light into a body the electrons of the body under the influence of rotating forces come into rotation, and if as a consequence friction arises from the material nucleus then also the material system experiences a certain moment of revolution. The work done per sec. is equal to $M\omega$, where $\omega = 2\pi/T$, and T is the period of the light. If the whole of the energy, E, of the light entering the body during 1 sec. is absorbed by it, then we obtain the equation $M\omega = E$, or $M = ET/2\pi$. Further, the transition is easy from the case of transformation of plane-polarised rays in a crystal to circularly polarised rays (Sadovski's), to that of the emission of circularly polarised light.

H. Busch, on the lines of the electronic theory, accepts as evident that if we revolve with angular velocity ω any substance whatever in a constant magnetic field, we shall obtain heat, and that this cannot arise from any cause other than that we expend in revolving the body a certain power—(the field does no work, retaining in itself its own energy)—$M\omega$; that is, we overcome a certain moment M. Whereupon there remains only to give, in addition, to the whole system a speed in the reverse direction ($-\omega$), in order to obtain an immovable substance in a rotating field, in which it is not possible to lose the mechanical indispensableness (*sic*) of the existence of the moment M (principle of relative motion). This case is no other than that of the electric motor with rotating field.

Consideration is brought to bear upon both the rotating electric field, from which emerges the Sadovski-effect, and the rotating Newtonian field of a kind like to that of solar and lunar attraction for an observer on the earth representing himself at rest. Whence is obtained a moment originating from the flow and ebb of the tide, and the consequent heating of the earth. All this is unified in the customary formula of the alternating-current electric motor, $M\omega = M\omega' + w$, where ω and ω' signify the rotatory velocity of the field of the stator and of the rotor itself, and w the Joulean heating of the rotor, which is nil, if the rotatory velocity of the rotor and of the revolving field are equal one to another.

The author proceeds to recall early conceptions of the nature of electricity in regard to its forming an integral part of matter. E. O. W.

580. *Frictional Electricity on Insulators and Metals.* **W. M. Jones.** (Phil. Mag. 29. pp. 261–274, Feb., 1915.)—In the work described the author examines the charges produced on various insulators and metals by known amounts of frictional work. The apparatus used is essentially the same as that of Owen [Abs. 1077 (1909)], the rubbing material being placed round the rim of a wheel against which the specimen, in the form of a disc, is pressed, the thrust between specimen and rubber being kept constant.

The insulators used were fused quartz, quartz crystals, ebonite, amber, sealing-wax, crystals of fluorspar, Iceland spar, and heavy spar, these being rubbed with flannel, silk, and chamois leather. Curves are given showing the relation between charge produced and work done; with a sufficient amount of work the charge rises to a constant maximum. Metals were rubbed by silk, to prevent leakage of the charge from the metal, and tested so far as possible with their surfaces in the same state, since reversals of sign took place in some cases if the surfaces became tarnished or if a roughened surface became polished. Au, Pt, Sn, Ag show a negative charge; Bi, Pb, Tl a positive; Sb, Zn, Cu, Fe, Al positive if polished, negative if roughened with emery. The sign and magnitude of the charge do not appear to be well-defined physical properties of the metals. The charges (as for insulators) rose to a constant maximum, but the charge generated by a given amount of work increases with the capacity of the specimen. It is found that rubbing insulators and metals in strong magnetic or electric fields does not affect the max. charge, which is also independent of temperature, pressure between rubber and specimen, and velocity of rubbing.

An attempt is made to explain the results on the assumptions that (1) the rubbing friction has the effect of removing electrons either from rubber or specimen at a rate proportional to the rate of working; (2) leakage of electricity takes place at a rate proportional to the charge present and to the rate at which fresh surface of the rubber comes into contact with the specimen.

It is found that $Q = (a/b)(1 - \epsilon^{-bw})$, where Q is the charge produced on the specimen by an amount of work w, a and b being constants during any one experiment. The theoretical curves show a fair agreement with those from experiment. The term a depends on the pressure between the bodies, but if a and b contain the same functions of the pressure as factors, then the max. value of Q is independent of the pressure. For metals Q will be proportional to the capacity if b is inversely proportional.

It seems probable that a satisfactory theory of frictional electricity might be formed on these lines. T. H.

581. *Electromagnetic Field in an Anisotropic Medium.* **M. Francesco.** (N. Cimento, 8. pp. 331–360, Nov., 1914.)—Mathematical.

582. *Atoms and Ions.* **J. J. Thomson.** (Engineering, 99. pp. 251–252, Feb. 26; 277–278, March 5; 303–304, March 12; 329–330, March 19; 356–357, March 26, and pp. 413–415, April 9, 1915. Lectures delivered at the Roy. Inst. Electrician, 74. pp. 776–778, March 12, and 75. pp. 20–22, April 9, 1915.)—These lectures deal with recent researches in this domain. No brief abstract is possible.

583. *The Potential in a Dielectric Sphere in a Uniform Field of Force.* **G. R. Dean.** (Electrician, 74. p. 657, Feb. 19, 1915.)—Gives a solution which is more direct and simple than that usually given in text-books.

L. H. W.

584. *Atmospheric Electric Potential Gradient at Kew Observatory*, 1898–1912. **C. Chree.** (Roy. Soc., Phil. Trans. 215. pp. 133–159, 1915.)—In an earlier paper the results for the 7 years, 1898–1904, were discussed. The present paper employs the longer period of 15 years which is now available. The observations of potential gradient employed are taken from the Kelvin water-dropping electrograph, and the question of the factor to be used to convert these readings into potential gradients in the open is fully discussed. Control observations in the observatory grounds have been taken over the whole 15 years, but it is only for the last 3 years that these have been carried out under such conditions that a close approximation to the undisturbed gradient could be arrived at. It is concluded that the figures for the years previous to 1910 require multiplying by the factor 1·91 to bring them into harmony with the more satisfactory values which have been obtained for the last 3 years of the period. It is not claimed that even now an absolutely full measure of the potential gradient in the open is being obtained; but the errors which remain are probably trifling compared with those which have been eliminated.

The results used are from selected rainless days, in general numbering 10 per month. The mean potential gradient for the whole year is found to be 304 volts/m., a very much larger value than that found in the past at most stations. The maximum and minimum of the yearly curve occur at about midwinter and midsummer, being 409 and 207 volts/m. respectively. The magnitude of the diurnal range of gradient shows a very similar annual variation to that of the absolute potential gradient with maximum and minimum occurring at the same seasons. It is pointed out that rapid changes in potential gradient must be associated with rapid changes in the surface charge of the earth, and these changes must be accompanied by air-earth currents or ground currents. It is found that the normal magnitude of the air-earth current is about 15 times as large as the current required to change the surface charge in the manner demanded by the diurnal change of potential gradient, even at the time of day when this change is most rapid. When the diurnal variation is harmonically analysed it appears that the semi-amplitude of the first or 24-hour term varies from about 60 volts/m. in midwinter to almost zero in the summer months, while the 12-hour wave shows much less seasonal variation. The mean of these 12-hour semi-amplitudes for the 12 months is 49 volts/m. The first and second Fourier coefficients have been calculated for each of the 15 individual years, and it appears that the 24-hour term data fluctuate very much more from year to year than do the 12-hour. Analysis of the annual potential curve shows that this departs very little from a pure sine wave of 12-month period.

J. S. Di.

DISCHARGE AND OSCILLATIONS.

585. *Photo-active Cells with Fluorescent Electrolytes.* **G. E. Thompson.** (Phys. Rev. 5. pp. 43–52, Jan., 1915.)—The efforts of previous experimenters to prove a dependence of the photoelectric current on fluorescence, in the case where two metal electrodes immersed in certain fluorescent solutions are unequally illuminated, have not led to definite results. Minchin and Hodge [Abs. 695 (1909)] suspected such a relation unlikely. The results now obtained show that the curves for the growth and decay of the photoelectric current are similar to those for the growth and decay of phosphorescence. If $I^{-1/2}$ be plotted, the characteristic broken line is obtained. The magnitude of the photoelectric current depends on the metal used as electrodes. Of ten metals tried, only platinum, gold, silver, and oxidised copper gave a measurable effect. The position of the max. effect does not depend upon the material of the electrodes but upon the material in solution; the effect is not the photoelectric effect of the metal in the liquid. The experimental results do not show any close connection between the photoelectric current and fluorescence. Two methods for increasing fluorescence did not increase the current. The region of excitation for the current extends further into the red than for fluorescence. All curves show the max. photoelectric current approximately in the region of max. absorption. A. E. G.

586. *On Ionisation.* **J. J. Thomson.** (Phys. Soc., Proc. 27. pp. 94–117, Dec. 15, 1914.)—Ionisation is the process by which ions—particles charged with electricity—are produced in a solid, liquid, or gas. This address is confined to the consideration of ions in gases and deals with two questions: (1) The nature of the ions, (2) the process by which they are produced. The evidence as to the nature of ions is derived from experiments on their mobility which have shown:—(α) The mobility of a positive ion depends only on the gas through which the ions are moving and not on the nature of the gas out of which the ions are formed. (β) The mobility of the ions in a gas at constant density is independent of the temperature. (γ) There are a considerable number of gases in which the mobility is very approximately inversely proportional to the square root of the density of the gas. (δ) In the case of negative ions there is an abnormal increase of mobility when the pressure is reduced below a certain value, and there is some evidence that this is also the case for positive ions at very low pressures.

Two theories of the mobilities of ions are considered, one founded on the view that the action between ions and molecules is analogous to impacts between hard elastic spheres, the other on Maxwell's theory of forces between ions and molecules varying inversely as the fifth power of the distance between them.

It is shown that (α) follows from the second theory provided the ion is a cluster whose mass is considerably greater than that of a molecule of the gas through which it is moving. On this supposition it follows also from the first theory if we suppose in addition that all ions in a given gas are of the same size.

(β) follows at once from the second theory; to explain it on the first theory we must suppose that the size of the ion varies with the temperature in a definite way. The necessary relation can be deduced from thermodynamical principles if we suppose that the force between an ion and a molecule is analogous to that between a charged point and a sphere which is either a conductor of electricity or has a high specific inductive capacity.

(γ) requires on theory one that the ions in these gases should be of the same size, on theory two that the molecules of these gases should exert the same force on a charged point at a given distance.

(δ) follows on either theory if the ion dissociates at low pressures so that free corpuscles are present in the gas.

With regard to the process of ionisation, the first stage of this in the vast majority of cases consists in the detachment of an electron or corpuscle. Evidence as to the method by which this takes place is afforded by determinations of the velocity with which the electrons are ejected from the body. In the case of ionisation by light or Röntgen rays, this velocity depends primarily on the wave-length of the radiation, not upon its intensity, nor, at any rate to any great extent, on the nature of the molecule from which the corpuscle is ejected. This velocity is far greater, even when every allowance is made for resonance, than can be accounted for if we suppose that the energy of the light is uniformly distributed, and that the corpuscle acquires its velocity by the action on it of the electric force in the wave. Another explanation not open to these objections is put forward.

When ionisation is due to the action of moving electrified particles, whether positive or negative, the results are quite different. The velocity of the ejected particles (δ-rays, as they are sometimes called) does not seem to vary much, if at all, with the velocity of the particles which eject them, and is of the same order whether these particles are positive rays or the much swifter kathode rays. The method of ejection by the impact of such particles is considered, and suggestions are thrown out as to a possible theory and some of its consequences. AUTHOR.

587. *Ionisation of Metals by Kathode Rays.* **N. Campbell.** (Phil. Mag. 29. pp. 369–383, March, 1915.)—The recent work of the author on the ionisation of Pt by kathode rays [Abs. 337 (1915)] has now been extended to other metals, namely Cu, Ni, Al, and to rays of higher speed. The method used is to allow kathode rays from a Wehnelt kathode to fall on a plate of the metal and to determine the reflection coefficient, $i_1 - i_2/i_1$, i_1 being the total current flowing to the plate, i_2 the current received by the plate when none of the electrons reflected by or emitted from it, fall back on to it. It is found that changes in the ionisation which take place on heating Pt, Cu, or Ni can be produced much more rapidly by using the plate as an electrode in a discharge through air, oxygen, hydrogen, or petrol vapour at about 2 mm. pressure. The changes appear to be connected with "sputtering," which would explain the fact that in Al hardly any change could be produced. From his observations the author classifies the metal surfaces, in respect of ionisation, into the following :—(1) State A, which is that after the metal has been polished, (2) states B′, which are produced by the discharge, of which one, B, is distinguished because it can always be reproduced in the metal, after discharge, by subjecting the surface to kathode-ray bombardment, and also because the ionisation in this state is greater than in any of the other states in this class. State A can be regained by heating in a Bunsen flame or by polishing. Thus there are two states of the metal which can always be reproduced, A and B, but A cannot be produced from B by kathode-ray bombardment as the author previously thought. It is suggested that the state A is that in which the metal is covered with a layer of gas, state B that with the layer removed. The reduction of ionisation below that in state B would then be due to some other change in the metal hindering the emergence of electrons, *e.g.* a roughening of the surface due to the sputtering and a consequent entanglement of the electrons or to a double-layer. On this hypothesis we should expect the ionisation potential in state A (metal covered with gas) to differ from that in state B (exposed metal), but experiment leaves it uncertain if any such difference exists; if the ionisation potential does differ, it is lower in state B. Other tests also failed to bear out the ideas, apparently showing that the differences between the states B′ must be due to some cause more complicated than an opposition to the emergence of electrons liberated in the metal. T. H.

588. *Qualitative Method of Investigating Thermionic Emission.* **F. L. Hopwood.** (Phil. Mag. 29. pp. 362–369, March, 1915.)—It has been shown previously [Abs. 942 (1914)] that the movement of charged bodies in the neighbourhood of a glowing carbon-filament lamp produces, under certain circumstances, a displacement of the loops of the filament. The results of a further study of the phenomena, and their application as a basis of a qualitative method of investigating the emission of electrified particles from incandescent bodies, are given in the present paper. When various carbon-filament lamps were heated above their ordinary temperatures by running the lamps above their normal voltage, they were found to be insensitive to the motion of charged bodies in their neighbourhood, although they were very sensitive to such motions at lower temperatures. It was sometimes found that filaments of high-candlepower lamps were also insensitive when run at their normal voltage, but sensitive at lower voltages. Three possible explanations of this null effect at high temperatures were tested experimentally, and it is concluded that the null effect is due to the emission of positive and negative ions in sufficient quantities to neutralise an induced charge of either sign on the filament, while the positive emission at lower temperatures is too small to dissipate the charges induced by a negatively charged rod sufficiently quickly to prevent the motion of the filaments. Experiments made with glowing Pt filaments in the open air tend to confirm this conclusion, for at a red heat they were found to be attracted by a positively electrified rod but not by a negatively electrified one, while at temperatures near the melting-point of Pt neither rod attracts the filament. It is well known that Pt in air emits chiefly positive ions at low temperatures and an excess of negative ions at high temperatures. The knowledge that a glowing filament is attracted by a rod charged with electricity of the same sign as the ions emitted by the filament, and that the *removal* of a rod charged with electricity of opposite sign causes a movement of the filament provided there is a solid dielectric between them on which to receive the ions, has been used as the basis of a qualitative method of investigating the thermionic emission of iron, nickel, copper, nichrome, brass, phosphor-bronze, silicon-bronze, platinoid, eureka, tinned copper, and galvanised iron. All of these were tested in air, and a few in hydrogen and CO_2. In every case they gave a positive emission.

The emissions from most of the alloys mentioned do not appear to have been investigated previously. A. W.

589. *Analysis of Gases after Passage of Electric Discharge.* **A. C. G. Egerton.** (Roy. Soc., Proc. 91. pp. 180–189, March 1, 1915.)—It has been found by Collie and Patterson [Abs. 1036 (1913)] that, after the passage of the electric discharge through pure hydrogen in a vacuum tube at low pressure, small quantities of He and Ne could be detected in the gas pumped out of the discharge tube. These gases were shown not to be present in the hydrogen which was let into the discharge tube. They must, then, either originate

from (1) occlusion of air in the glass or electrodes, or (2) from the outer air during the experiment or the subsequent analysis, or (3) be actually formed by some transmutation process due to the action of the discharge. In the latter case the seat of the effect of the discharge may be at the solid electrode, glass walls, or in the gas itself. These previous experiments appear to show that the hydrogen (or possibly the glass tube) had in some way been affected by the discharge, so as to obtain He or Ne. It is noteworthy that positive results of the production of He or Ne are only sometimes obtained. J. J. Thomson had noticed that helium lines were always very marked in the positive-ray spectrum produced during the bombardment of metallic substances by kathode rays, when only pure hydrogen had been allowed to enter the discharge tube. He favoured the view that the metallic electrodes were responsible for the production of the He, and that it might have been formed by slow radio-active processes and only liberated by the kathodic bombardment. Subsequently R. J. Strutt obtained no trace of He or Ne in the gas, which was analysed after passage of the discharge. He held that the gases could not be safely transferred by means of small inverted tubes over mercury without the possibility of a trace of air entering during the process, and this led him to construct an apparatus which was entirely self-contained, and by means of which all external transference from the discharge tube to the analysis apparatus was entirely avoided. The work of these investigators has not, therefore, led to similar results, and the following questions present themselves: First, were the electrical conditions of Strutt's experiments unfavourable to the formation of rare gases? Secondly, was the method of analysis less sensitive? Thirdly, is it possible to prevent access of air into the apparatus during the experiment and analysis and entirely to free the electrodes of all detectable traces of rare gases?

In the work here described, which was carried out in continuation of some other work along similar lines, special attention has been paid to these points. The attempt to produce rare gases (Ne and He) in accordance with the experiments of Collie and Patterson, by the passage of an electric discharge has not been successful. Both from theoretical and experimental standpoints it is held that if such a production has an origin other than from atmospheric contamination the source must be looked for in some action on the solids which compose the discharge tube (electrodes or glass) rather than from the gases. A. E. G.

590. *Electric Field in the Hittorf-Crookes Space and the Electrical Decomposition of the Spectral Lines.* **A. Lo Surdo.** (Accad. Lincei, Atti, 23. pp. 117–122, Aug. 16, 1914.)—The strength of the electric field in the dark space depends essentially on the fall of the kathodic potential, that is, on the complex p.d. between the kathode and the limit of the dark space, and in the length of this space and the law according to which the potential is distributed in it. Admitting the validity of Stark's law, $K = K_n + k(C - xpf)^{\frac{1}{2}}/pf^{\frac{1}{2}}$—where K is the kathodic fall of potential, K_n its normal fall, C the current at gas pressure p, f the area of the kathode, and k and x are constants—it is shown that the increase in the kathodic fall of potential at a certain pressure depends solely on the current density at the kathode; the same kathodic fall may thus be obtained in wide tubes as in narrow ones, if the current is increased proportionately to the section. Further, it is found experimentally that, when the plane electrode completely fills the section, the length of the dark space is independent of the diam. of the tube. According to Stark, the distance between the components of the spectral lines decomposed by the electric

field is proportional to the electric force. When the image of the kathode space of a tube parallel to the slit of a spectroscope is projected on to the slit each component has the form of the curve representing, on orthogonal axes and corresponding units, the relation between the intensity of the electric field—measured on an axis perpendicular to the slit and hence to the undecomposed line—and the distances from the kathode, measured along the undecomposed line. By photographic methods and by direct observation it is found that, with the tube parallel to the slit, the decomposition of the spectral lines always exhibits a Y-shape. The undecomposed line, and hence the axis of kathode-distance, is vertical and coincides with the lower part of the Y, and each of the two branches, that is, each of the components, represents the distribution of the field; the point of convergence corresponds with the limit of the dark space. These components are almost rectilinear, so that the course of the field is nearly that given by Schuster (Roy. Soc., Proc. 47. p. 526, 1890), and, as a first approximation, may be regarded as linear. [See Abs. 666 (1914).] T. H. P.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

591. *Most Effective Adjustment of an Induction-coil.* **E. T. Jones.** (Phil. Mag. 29. pp. 1–15, Jan., 1915.)—The author has shown in a recent paper [Abs. 1314 (1914)] that the secondary potential and spark-length developed by an induction coil, when a given current is interrupted in the primary, are greatest when (I) the ratio n_2/n_1 of the two oscillation frequencies of the system has one of the values 3, 7, 11, ..., and (II) $L_1C_1 = (1-k^2)L_2C_2$, where L_1, L_2 are the self-inductances, C_1, C_2 the capacities, and k is the coupling coefficient of primary and secondary. Condition (I) is that maxima of the two potential-waves in the secondary should occur simultaneously, and (II) that the sum of the amplitudes of the two waves should be a maximum for a given value of k. It was also found that the most effective of the ratios specified in (I) was $n_2/n_1 = 3$ and that in this case $k = 0{\cdot}756$ and $L_1C_1 = 0{\cdot}429L_2C_2$. The author now considers the application of Dibbern's formula to the p.d. between the plates of the primary condenser. At time $t = 1/4n$, when conditions (I) and (II) are satisfied and neglecting resistances the amplitudes of the two potential-waves in the primary are equal and opposite and are a maximum. The primary condenser is therefore uncharged while at the same moment the secondary potential is at its maximum. The whole of the energy at this moment exists in the electrostatic form in the secondary. For an ideal coil the efficiency is unity under the conditions given above. The author concludes that any induction-coil in which the coupling is greater than 0·756 can be improved in spark-length by inserting external series inductance in the primary so as to reduce the coupling to this value. An induction-coil should not be constructed so that the coupling is less than 0·756, for there is no convenient way of increasing its value. The theoretical conclusions apply strictly only to an ideal induction-coil in which resistances and other causes of damping are negligible; but the author shows by further experiments carried out on the lines of his well-known previous work that the results of theory agree closely with experiment in so far as they concern the conditions which determine max. spark-lengths. The actual value of the secondary p.d. is of course greatly modified by damping. I. W.

592. *Mechanical Analogue of Coupled Circuits.* **T. R. Lyle.** (Engineering, 98. pp. 580–581, Nov. 13, 1914. Paper read before the British Assoc., Australia.)—The device described consists of a truck provided with wheels made out of steel discs, the truck being free to move on bevelled glass plates. Two pendulums are supported from the truck beam and the oscillations of the swinging pendulums are used to demonstrate the influence of coupling (*e.g.* increased by loading the truck). L. H. W.

593. *Silver and Iodine Voltameters.* **G. W. Vinal** and **S. J. Bates.** (Bureau of Standards, Bull. 10. pp. 425–450, April 15, 1914.)—[The full paper corresponding to Abs. 1608 (1914).]

594. *Valve-cell Rectifier.* **H. Greinacher.** (Deutsch. Phys. Gesell., Verh. 16. 7. pp. 820–826, April 15, 1914.)—The currents given by electrolytic rectifiers not being of sufficiently constant pressure for certain purposes, the author describes several combinations of alternating-current generators and valve cells suitable for producing constant currents of 10^{-4} amp. maximum such as he wants for his direct-reading ionometer (ionisation of the air), for instance. Into the two leads of an alternating generator for 200 or 220 volts he inserts two batteries, each of four electrolytic cells, and connects a condenser across the two mains, from the ends of which he can then take current at $200\sqrt{2} = 288$ volts. On 100-volt circuits the shunt consists of two condensers in series; the point between the two condensers being joined to the one terminal, whilst the two batteries are connected to the second terminal. The author is aware that similar proposals were made by P. Villard in 1900. He tests his combination, which is also suitable for enlarging the test range of electrostatic voltmeters, with the aid of a Wulf bifilar electrometer. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

595. *Wiedemann Phenomenon in Nickel Wires.* **T. Gnesotto** and **V. Mattioli.** (N. Cimento, 8. pp. 379–402, Nov., 1914.)—The researches on the torsion produced in a nickel wire under tension when subjected to a longitudinal magnetic field due to a solenoid and a circular field due to a current in the wire itself, are continued [see Abs. 937 (1912), 751 (1914)]. The tables and curves for three sets of experiments are given. In the first set both the current producing the longitudinal field and that producing the circular field vary cyclically, but have a constant ratio one to the other. In the second, the current in the wire is constant but the other varies cyclically; and in the third, the current in the wire is constant but that which produces the longitudinal field varies cyclically.

In all the cases steady cycles of torsion are attained. S. G. S.

596. *Magnetic and Mechanical Properties of Manganese Steel.* **R. A. Hadfield** and **B. Hopkinson.** (Iron and Steel Inst., J. 86. pp. 106–121; Disc. and Corresp., 122–187, 1914. Electrician, 73. pp. 304–305, May 29, 1914. Engineering, 97. pp. 756–759, May 29, 1914.)—When quenched in water from 1000° C., a steel containing about 1¼ % C and about 12 % Mn has a Brinell hardness number of about 200, a tensile strength of 54 to 63 tons per sq. in. with an elongation of 30 to 50 %, while at the same time it is so tough that it can be bent double. In this condition it is practically non-magnetic, but magnetic properties can be conferred upon it by heating to a high temperature followed by slow cooling. Experiments have been carried out with a view to determining the magnetic qualities of the water-quenched material after prolonged

heating at various temperatures. It was found that the material was rendered magnetic by heating at temperatures below 500° C., but that the rate of the change was very slow. At temperatures between 500° and 520° C. the rate of change was much more rapid, being fairly complete after about 600 hours. It would appear that if the experiment were prolonged for a sufficient time the specific magnetism-time curve would become asymptotic to a line representing the limit of magnetism possible at that particular temperature. Above 520° C. the change was relatively rapid but the asymptote to which the curve approached appeared to be lower than that proper to 520° C., at which temperature the material became more magnetic than it could be made at any other temperature. At temperatures above 700° C. the material became only very slightly magnetic, in fact the fully magnetic material was rendered non-magnetic by a few minutes' heating to 750° C. The non-magnetic material and the material in which the magnetic properties were fully developed were not affected by immersion in liquid air, but the properties of the intermediate material were found to be improved by this treatment. Heating-curves of a steel which had been rendered magnetic showed a critical point at about 700° C., but there was no corresponding evolution of heat in the cooling curve. It would appear that at all temperatures up to 750° C. the stable form of the alloy is more or less magnetic, while above this temperature the stable form is non-magnetic. Between 750° and 650° C. there is a critical range corresponding to the loss of magnetism in ordinary carbon steel. The effect of the Mn is to retard the attainment of equilibrium rather than to produce any marked shift of the critical range. As the magnetic qualities of Mn steel improve, the mechanical properties deteriorate. A steel having only 1 % of the magnetism of pure iron is so brittle as to make it unfit for use in practice. The change from the non-magnetic to the magnetic state is accompanied by a characteristic alteration in the microstructure. The water-quenched material has a polygonal structure but after heating for 6 hours at 400° C. the surface becomes covered with interlacing needles. When the material is rendered quite magnetic the structure is martensitic in character. Somewhat similar changes have been observed in a quenched 2 % carbon steel both as regards recovery of magnetic properties on tempering and in the alteration in the microstructure. F. C. A. H. L.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

597. *Rapid Process for Obtaining Radiographs upon Metal.* **Rivier** and **Dupoux**. (Comptes Rendus, 160. pp. 146–147, Jan. 25, 1915.)—Metallic plates known as ferrotype plates are used for obtaining direct positives. Extremely hard rays (9 to 10 B.) are used, with a max. current of 2 milliamps. in the tube. It is claimed that besides being extremely simple in manipulation, this process has the important advantage of being rapid. A finished positive proof is obtained in less than 10 minutes. The danger to the patient is likewise removed. A. E. G.

598. *New Form of Pole-pieces for Electromagnets for Surgical Purposes.* **Brandt** and **D. du Rousset**. (Comptes Rendus, 160. pp. 169–170, Feb. 1, 1915.)—Description of articulated pole-pieces by means of which a strong magnetic field may be applied to any part of a patient at a considerable distance from the actual electromagnet. G. E. A.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

599. *Diffusion of Hydrogen through Palladium.* **A. Holt.** (Roy. Soc., Proc. 91. pp. 148–155, Feb. 1, 1915.)—Experimenting together with Edgar and Firth the author had found that the rate of diffusion becomes more rapid with rise of temperature, but that any particular temperature is not characterised by any definite rate. The rate depends on the "activity" of the Pd-foil, its power of rapid occlusion of the gas; the greater the activity, the greater the rate of diffusion. Most of the experiments made concern the temperature range 180° to 800° C., and the pressure range 700 to 100 mm. What is measured is not the actual volume of gas diffusing through the metal, but the variation of pressure with the change, the rate being taken to be the number of seconds required for a change in pressure of 1 mm. Hot palladium is rapidly saturated with hydrogen. The gas seems to diffuse through the metal at a rate proportional to the pressure, not to the square of the pressure. The intramolecular gas hence would appear to be in a simple molecular condition; but the occlusion seems to be complex, the rate-curve appearing to consist of two portions, and the peculiar form of the rate-curve may be attributed to two modifications of the metal, differing solely in the packing of the material. A similar assumption had been made with regard to the rate of solution of hydrogen at constant pressure by Pd-foil. Below pressures of 100 mm. the rate of diffusion becomes more and more slow, and does not appear to be related to any simple function of the pressure. H. B.

600. *Salts Coloured by Kathode Rays, and the Molecular Force-field Theory.* **E. C. C. Baly.** (Chem. News, 111. pp. 85–86, Feb. 19, 1915.)—It has been shown by Goldstein [Abs. 126 (1915)] that, under the influence of either kathode rays or ultra-violet light, coloured and metastable modifications of certain salts are formed which are characterised by new properties. This phenomenon, for which the name "distension" is suggested, is not shown by pure salts but is peculiar to solid solutions. In several recent papers the author has developed a theory of chemical reactivity based on an extended series of observations of the absorption spectra of organic compounds. In the present paper the bearing of this theory on Goldstein's results is discussed, and it is shown that the new highly coloured salts conform in every way to the deductions made from the field-of-force theory, and it only remains for their abnormal reactivity to be proved. The existence of these metastable phases has been demonstrated in the case of many organic compounds, but Goldstein's discovery is the first indication that they are formed also by inorganic metallic salts. T. H. P.

601. *Notes on Glass.* (Nature, 95. pp. 78–80, March 18, 1915. Chem. News, 111. pp. 133–135, March 19, 1915.)—These notes give the results of recent experimental work carried out on glass-ware of various kinds at the National Physical Laboratory, and are published for the benefit of manufacturers.

The first table gives the results of analyses of various thermometric and chemical glasses. Beakers and flasks of "R," Jena and Bohemian glasses were subjected to the action of water at 20° and 80° and to that of

$2N-NaOH$, $N-H_2SO_4$ and $2N-Na_2CO_3$ at 100° for definite periods, the loss in weight in mgm. per sq. dm. of surface being given in each case. Similar tests were made on the new Jena glass introduced a few years ago, unannealed vessels as well as others which had received ordinary annealing or special annealing for 86 hours in sulphurous gases. This glass exhibits slightly greater resistance to the attack of water, but no improvement in regard to the action of alkaline solutions. It possesses in a high degree the ability to withstand sudden change of temperature; a flask of the glass, filled with molten paraffin wax at 250° broke when placed suddenly in water at 15°, but only after successfully standing such a test at slightly lower temperatures.

Another question engaging attention is glass for miners' lamps, incandescent chimneys, steam-gauge tubes, and other purposes in which a temperature gradient is established between the inside and the outside. The compositions of various French, German, and Austrian lamp-glasses are given. It appears that the additional strength of the German glass is due largely to the thermal treatment, and optical tests have been made to elucidate the condition of strain in the glass, miners' lamp chimneys of German white glass and French yellow glass, and a piece of chemical "Durax" tubing being examined. With open and closed rings of the French glass, and with an open ring of the German glass, the strain found is negligible. An unbroken ring of the German glass showed decided strain, as did also both rings of the Durax glass. The German glass seems to be made in a single operation, but the Durax glass is probably built up of several layers of the same or different materials, brought together with one layer decidedly cooler than another.

Experiments were also made to determine possible variations in the strained condition of lamp chimneys due to internal heating and resulting temperature gradient. The French chimney was without strain when cool, but strain developed progressively as the temperature was raised, and apparently did not decline again to a minimum. When cool and at uniform temperature the German chimney showed marked strain, which is relieved but never entirely disappears on heating.

The incandescent lamp chimneys are too thin to admit of optical examination, but here also the extra strength is almost certainly attained by chilling the outside before the interior cools. The heat-resisting qualities of certain beakers, flasks, etc., of German glass may be due to the converse process, the interior being chilled previously to the exterior. All these glasses appear to be of the borosilicate type, and the chemical glass contains zinc oxide, which is absent from the thermometer glass. T. H. P.

602. *Silicised Carbon. Silfrax.* **F. J. Tone.** (Am. Electrochem. Soc., Trans. 26. pp. 181–190; Disc., 190–198, 1914. Met. and Chem. Eng., 12. p. 710, Nov., 1914.)—When solid carbon is acted on by an excess of the vapours of silica or silicon, an amorphous yellow product is formed in the amorphous zone of the carborundum furnace between 1550° and 1820°; at higher temperature, up to 2220°, a crystalline steel-black product of metallic lustre is obtained. The former product is called silfrax; both the products are carbon silicide, SiC, or carborundum. Carborundum and silicon are mutually soluble in one another. Silundum is also essentially SiC, impure like the others with SiO_2. The conversion of carbon into its silicide is generally explained by the equation: $SiO_2 + 3C = SiC + 2CO$. That would account for the fact that the conversion seems to take place *in situ*, the crystals or aggregates being of the shape and size of the original carbon particles. But in cavities large crystals are formed; when they are decomposed by high temperature, the skeleton of carbon left behind has again the shape of the crystal. Since carbon has no appreciable vapour pressure, the author assumes that the reaction is expressed by the reversible equation:

$$2CO + 3Si \rightleftharpoons 2SiC + SiO_2.$$

The first formula would explain the formation of silfrax, the latter that of the crystallised silicon carbide. Silfrax is a material for refractory articles. During the *discussion* **F. A. J. FitzGerald** showed some experiments intended to prove that carbon itself is volatilised and has an appreciable vapour pressure, which statement **J. W. Richards** supported; in the author's opinion access of air would account for some of those observations. **H. W. Gillett** stated that silfrax can be made into pyrometer tubes; but the tubes are not strong enough mechanically, when thin, and are hence placed over a sheath of nickel with a small molybdenum tube at the end. Base-metal couples deteriorate when in direct contact with silfrax; for this reason, silfrax being permeable to fine vapour, they require an impervious glaze on the inside if used with optical pyrometers. H. B.

603. *Electric Synthesis of Colloids.* **J. Mukhopâdhyâya.** (Am. Chem. Soc., J. 37. pp. 292–297, Feb., 1915.)—The formation of sols by Bredig's electric method is regarded by some authors, including Ostwald, as electrochemical in nature, the substance going into the liquid in the atomic form under electric stresses and subsequently undergoing aggregation. Benedicks and others, however, lay stress on the thermal side of the process and are of opinion that the metal partly volatilises and partly melts into fine drops, which remain in suspension. In order to investigate this question, an arc was struck under water between two carbon electrodes, one of which was partially coated with a non-conducting substance insoluble in water. In this way, sulphur, selenium, and phosphorus readily yield colloidal solutions, the selenium sol improving on standing, possibly owing to the oxidation of hydrogen selenide by atmospheric oxygen. All these sols are fairly stable and exhibit the Tyndall phenomenon, the cone of light breaking up and ultimately disappearing on addition of an electrolyte. Sols of cadmium and copper, prepared in this manner, are unstable and soon coagulate, the precipitate consisting of a mixture of metal with hydroxide in the former case and with oxide in the latter. With mercury, a good yield of a stable, grey sol is rapidly obtainable. Since it is known that heat alone may lead to the formation of sols, it seems probable that the electrical formation of sols is a thermal process induced by the high temperature of the arcing electrodes. T. H. P.

604. *Chemical and Mechanical Relations of Iron, Tungsten, Nickel, and Carbon.* **J. O. Arnold** and **A. A. Read.** (Inst. Mech. Eng., Proc. 2. pp. 223–267; Disc., 267–279, March–May, 1914. Engineering, 97. pp. 433–436, March 27, 1914.)—A summary is given of the authors' previous researches on the carbides of iron, manganese, chromium, and vanadium, and also summaries of the work of previous investigators on the carbides of tungsten and nickel. The tungsten steels used in the research contained from 2·88 to 26·29 % tungsten and about 0·7 % carbon. The results of tensile tests and alternating stress tests are given. Details are supplied of the method of separating the carbides by electrolysis in dilute hydrochloric acid and also analyses of the carbide residue obtained. These analyses show that in low-tungsten

steels the carbon is present as WC together with Fe_3C and the residue contains free carbon from the decomposition of the carbides. In steels containing over 11 % tungsten, the carbon is present as WC, and there is also present in the steels a tungstide of iron, Fe_2W. The results of microscopic examination show the presence of three new constituents: tungsten pearlite which seems to present only the sorbitic variety of pearlite; tungsten cementite which has been obtained on annealing high tungsten alloys and resembles iron cementite, being the result of the segregation of the WC of tungsten pearlite; and tungsten hardenite which forms from tungsten pearlite progressively and slowly, the transformation beginning about 850° C. and apparently being completed at 1150° C. The results of the research show that tungsten resembles vanadium in some respects, but its action is much less marked; for instance, it forms no double carbide, it entirely displaces Fe_3C, but whilst vanadium effects this displacement when only about 5 % V is present, it requires about 11 % W to expel the carbide of iron. High tungsten also accelerates the segregation of the carbide of tungsten in sorbitic tungsten pearlite into tungsten cementite, just as high vanadium hastens the segregation of V_4C_3 of sorbitic vanadium pearlite into vanadium cementite. On the other hand, the action of W differs from that of V in that whereas vanadium pearlite transforms with a marked thermal abruptness into vanadium hardenite at about 1400° C., the transformation of tungsten pearlite into tungsten hardenite spreads over the wide range of 300 deg. before completion. There is a further difference in that the ultimate results of the transformation of tungsten pearlite into tungsten hardenite are modified in high-tungsten steels by the presence of a stable, hard tungstide of iron whereas no similar vanadide of iron is present in high-vanadium steels.

In the case of nickel steels previous experience had shown that in a steel containing 0·5 % carbon and 10 % nickel, annealing had resulted in the dissociation of nickel carbide, the carbon being thrown out as well-crystallised graphite. In the present research, nickel steels were examined as received from the forge so as to prevent, if possible, the decomposition of the nickel carbide. In this case also, however, a small separation of graphite began (owing to the low manganese, 0·15 %) when only 3 % Ni was present, and in the presence of 7 % Ni and 1 % C, 42 % of the total carbon separated as graphite. It was therefore decided to use cast bars, cooled as quickly as possible in the air. In this way 4 bars were prepared containing respectively 3·25, 7·89, 20·34, and 30·43 % Ni. In the 30 % nickel bar containing 0·7 % carbon, the max. percentage of graphite was found, namely 0·13 %. On examination of the carbide results obtained by electrolysis, it was found that with steels high in carbon and containing up to 8 % Ni, the carbide Ni_3C exists only in negligible proportions. With carbon about 0·8 %, associated with 20 to 30 % of nickel, NiC assumes the supremacy. It is thus concluded that in ordinary somewhat manganiferous structural steels containing up to 7 % Ni, the nickel is not associated with the carbon but is alloyed with the Fe and Mn. Evidence is put forward in support of the contention that there is a definite alloy of iron and nickel corresponding to the formula Fe_7Ni which has very remarkable mechanical properties. It is shown that the combination between carbon and nickel in the carbide Ni_3C is of a very feeble description and that this carbide readily dissociates into its elements under the influence of annealing, rolling or hammering, or electrolysis. As a result of microscopic examination of the specimens it appears that in high-nickel and -carbon steels there is a constituent, nickel hardenite, which is relatively soft. There is no reason to suppose that there is a nickel pearlite, but rather that the Ni_3C is always in solid solution as nickel hardenite, which, on annealing or rolling, precipitates practically all its carbon as graphite owing to the unstable nature of Ni_3C. C. O. B.

606. *Influence of Nitrogen on the Mechanical Properties of Iron.* **N. P. Tchijevski.** (Rev. Soc. russe de Métal. 1. pp. 185–189, 1913. Rev. de Mét. 11. E. pp. 618–620, Sept., 1914.)—Samples of iron containing from 0·00328 to 0·393 % nitrogen were prepared by heating soft-steel wire in an atmosphere of ammonia at 900° C. for times varying from 1 min. to 30 mins. Uniformity in composition was attained by subsequently annealing in an atmosphere of nitrogen for 4 hours at 1100° C. After such treatment the surface of the wire remained silver white, but the surface became more and more frosted as the content of nitrogen increased. Nitrogen caused a rapid increase in the elastic limit and the ultimate strength, with a corresponding decrease in the elongation. F. C. A. H. L.

606. *Iron and Nitrogen.* **N. P. Tchijevski.** (Rev. Soc. russe de Métal. 1. pp. 127–135, 1913. Rev. de Mét. 11. E. pp. 617–618, Sept., 1914.)—Various samples of iron alloys were found to contain the following amounts of nitrogen:—Cast iron, 0·0011 to 0·00326 %, open-hearth steel, 0·00312 to 0·00433 %, and bessemer steel, 0·0135 to 0·0153 %. The author has made a study of the conditions under which iron, and the elements contained in the commercial varieties, combine with nitrogen. Pure dry nitrogen does not combine with iron at any temperatures, but in the presence of ammonia combination does take place, the greatest activity occurring at about 450° C. Therefore under the conditions existing during its manufacture iron does not possess the faculty of combining with nitrogen. Carbon plays no part in the relations existing between iron and nitrogen. Manganese forms two nitrides, Mn_3N_2 and MnN, and at 1000° C. combines pretty rapidly with nitrogen itself. It has also been shown that manganese steels possess the property of absorbing nitrogen when heated in the gas. Silicon also forms a number of nitrides which have been shown to be soluble in iron. It is possible, therefore, that the joint action of Mn and Si account for the presence of nitrogen in iron and steel. There is, however, another possible means of introducing it, and that is through the agency of the Al which is often used in small quantities in the making of steel. The author has proved that the aluminium nitride AlN can form a solid solution with iron. F. C. A. H. L.

607. *Recrystallisation of Deformed Iron.* **C. Chappell.** (Iron and Steel Inst., J. 89. pp. 460–498, Corresp., 499–502, 1914.)—The author has studied the transition of the elongated ferrite crystals produced by severe cold-working, into those of the normal allotriomorphic shape. Recrystallisation takes place in three stages which overlap to a degree depending upon the amount of cold work to which the metal has been subjected. Up to 500° C. no changes occur in the crystal boundaries, but within the crystals themselves changes begin at about 350°, the grains developing a rough granular appearance on etching. The appearance indicates disintegration and incipient recrystallisation about the planes along which deformation has taken place during cold-working. This disintegration continues up to 500°. Above 500° (second stage) minute but quite independent crystals make their appearance inside the granular etching areas. When once formed, these minute crystals grow very rapidly into crystals of normal allotriomorphic shape. This stage completes itself at about 570°. Above 570° the third stage sets in,

and the crystals increase steadily in size up to 700°, above which temperature there is little alteration in the crystals until Ac3 is passed, when complete recrystallisation occurs. These results give strong support to the view that in addition to the physical equilibrium between two or more phases, there exists a structural equilibrium between the parts of a phase. Examination of heated, locally deformed pure irons shows that at temperatures between 650° and 900° three zones may be developed at each point of deformation, viz., an inner zone in which max. deformation has taken place and in which the crystals developed are of normal allotriomorphic shape not materially different in size from those of the undeformed material; an outer zone, in which the plastic deformation is less but the crystals have grown to an enormous size; and an unchanged zone, in which no plastic deformation has occurred and the crystals are unchanged. Further study shows that the inner zone is not one in which no change occurs, but that it is a zone in which recrystallisation sets in at a lower temperature. In the outer zone max. growth takes place between 700° and 800°. The temperature of recrystallisation (temperature at which the time factor is zero) increases as the degree of deformation decreases. The A2 point has no influence on the recrystallisation phenomena. The lower limit of the stress required to produce these recrystallisation effects practically coincides with the yield-point of the material. Interesting results are obtained by the examination of tapered tensile test-bars which, when broken, give a continual increase of stress from the yield-point to the max. stress. The largest-sized crystals occur at the yield-point where the large crystals abut directly on to unchanged ones. At the end of the fracture even refinement of the crystal size may be attained. This is due to the fact that the recrystallisation is not simple, but consists of a refinement followed by growth. The more highly strained portions undergo a greater degree of refinement, with the result that the diminution in crystal size exceeds the subsequent growth. The ultimate crystal-size attained on annealing is therefore to be regarded as the resultant of two opposing forces, one tending towards refinement and the other towards growth. Tapered bars broken at temperatures increasing by 50-deg. intervals from 100° to 1000° and subsequently annealed at 850° for 40 mins. show that coarse crystallisation develops in all the bars up to 870°, but in none broken above 900°. A bar broken at 870° and maintained at this temperature for a further 30 mins. develops crystals of a phenomenal size. Examination under high powers indicates that at high temperatures deformation takes place first along the cleavage planes. The effect of carbon is to restrict the size of the crystals developed, and to make a higher degree of stress necessary to produce growth. At the same time the temperature at which the gross crystallinity is destroyed, is lowered. These recrystallisation phenomena can be utilised to show the lines of flow produced in the mechanical testing of iron by both static and dynamic methods. In a tensile test-piece the coarse crystallisation produced on subsequent annealing follows the Lüders lines, and it is suggested by the author that the rectangular brittleness in sheet steels is due to this recrystallisation. F. C. A. H. L.

608. *Recent Improvements in Case-hardening Practice.* **H. L. Heathcote.** (Iron and Steel Inst., J. 89. pp. 342–372; Disc. and Corresp., 373–377, 1914.)—The author describes improvements made in the case-hardening practice of the Rudge-Whitworth works. Furnace temperatures are controlled by means of a form of optical pyrometer in which the work is viewed through a column of dye solution. In one form the instrument is a binocular one,

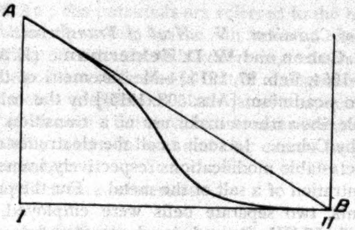
and the dye solutions are contained in a series of cells, each pair of which is capable of absorbing all the light rays emitted from the work up to a particular temperature. Up to this temperature the work is invisible through the instrument, but above, light is transmitted and a fresh pair of cells, corresponding to a higher temperature, have to be introduced. In another form a range of absorptive powers is obtained by means of a tube with collapsible sides, so that the length of the column of dye solution can be varied by causing the ends to approach or retreat from each other by means of a graduated screw. An investigation of case-hardening compositions showed that they varied enormously in composition, permanence, and permeability to heat. Very much better results were obtained in all these respects by the application of wood charcoal impregnated with soda ash. Finely-divided mixtures heat up much more slowly than coarse ones. On reheating, the temperature rises more rapidly than on the first ignition. For testing hardness an interesting form of sclerometer has been devised. In its simplest form, for testing the hardness of small cylindrical articles, it takes the form of two fine files, one of which is fixed in a horizontal position while the other is pivoted at one end. The article to be tested is placed between the two files and allowed to roll along the lower file under the influence of the weight of the upper one until equilibrium is attained and the pivoted file comes to rest at an angle which increases as the hardness of the article decreases. This angle is a measure of the hardness of the test object. Mathematical investigation shows that the angle is independent of the weight of the files or the object, but that it increases as the diam. of the object decreases. Various types of the instrument, each for its own particular purpose, are illustrated and described. Variations in the hardness of quenched articles can be shown by brightening them and then immersing them in a solution of 100 c.cm. pure nitric acid in a litre each of water and alcohol. Differences in hardness are at once revealed by variations in the colour of the articles after immersion. F. C. A. H. L.

609. *Alloys with Remarkable Properties at Very High or Very Low Temperatures.* **L. Guillet.** (Rev. de Mét. 11. pp. 969–970, Sept., 1914.)—A remarkable alloy, designated ATG, has been produced at the Imphy steel-works. It consists of a high-percentage nickel steel, stiffened by the addition of chromium and tungsten, and at the ordinary temperatures shows a tensile strength of about 80 kg. per sq. mm. with an elongation of 42 %. At 800° C., its tensile strength is 24 kg./mm.^{2} and its elongation 28·5 %. An ordinary steel having a tensile strength of 90 kg./mm.^{2}, with an elongation of 53 % at room temperatures, has, at 800° C., a tensile strength of only about 7·5 kg./mm.^{2}, with an elongation of only 6 %. Another alloy, designated AMF, has a resilience (Fremont) of about 50 kg.-m. at — 195° C., the resilience of soft steel at the same temperature never being more than 3 kg.-m. In his treatise on Metallography, Tammann describes two alloys which have remarkable strengths at high temperatures. The first contains 25 % chromium and 75 % cobalt. At 720° C. its tensile strength is 44·9 kg./mm.^{2} and its elongation 21 %. At the same temperature, an alloy containing 30 % Cr and 70 % Co has a tensile strength of 65·1 kg./mm.^{2}, with an elongation of 8·6 %.

F. C. A. H. L.

610. *Experiments on Allotropy of Iron: Behaviour of Ferro-magnetic Mixtures; Dilatation of Pure Iron.* **C. Benedicks.** (Iron and Steel Inst., J. 89. pp. 407–443; Corresp., 444–459, 1914.)—A difficulty attached to the

author's beta iron theory is that if there is no discontinuous transition between the α and β states, then there is no reason for the chief part of the magnetic change occurring within a very narrow interval of temperature below A3. Recent work by Burgess and Crowe [Abs. 1002 (1913)] indicates that A2 thermal coincides with the temperature of the most rapid disappearance of ferromagnetism. It may be, however, that the intensity of magnetisation of mixtures of a ferromagnetic substance I and a non-magnetic substance II does not follow a straight line, but that it follows a curve similar to the one indicated in the accompanying diagram. Experiments made on magnetite-quartz, iron-copper and nickel-copper mixtures gave magnetic curves very much like the one indicated in the Fig. The approximation to the hypothetical curve appears to increase with the degree of fineness of the mixture. Applied to the case of the α–γ iron complex, this indicates that there must be a certain narrow interval of temperature in which the bulk of the magnetism is lost, and this is the point A2 magnetic. According to the Langevin-Weiss theory, a loss of ferromagnetism is always accompanied by a slight absorption of heat, and this accounts for the appearance of the point A2 thermal. The behaviour of Hadfield's manganese steel is considered to lend support to the author's theory, the steel in the intermediate state realising at room temperatures the molecular state of pure iron above A2. The bulk of the iron has been transformed into the α state, but there is still too much γ-iron present to permit of the appearance of ferromagnetism.



For the study of the dilatation of iron, a very sensitive differential dilatometer was devised in which it was possible to measure the length of the samples used (90 mm.) with an accuracy of 8×10^{-6} per cent. The results show that there is an enormous change in length at 910° C. corresponding to A3. This change is very sharp, indicating that there is little or no mutual solubility between the α and γ phases. At A2 there is a slight continuous deviation and, if there is a discontinuity at all in this region, it is only of the order of about 3/1000 of that occurring at A3. The slight changes in length are most probably connected with magnetostriction. Measurements of the magnetostriction show that it increases with rise of temperature until it attains a maximum between 500° and 550° C., after which it falls towards the temperature of disappearance of magnetism. At the temperature of the A3 point, iron has a very high internal mobility. This is shown by the fact that even under the low loads used in the dilatation experiments the samples heated to this temperature always showed a very considerable increase in length. The results are discussed very fully from a theoretical standpoint in connection with the author's theory, and it is considered that A2 is not a true allotropic transformation-point. F. C. A. H. L.

611. *Titanium and its Effects on Steel.* **G. F. Comstock.** (Ind. and Eng. Chem., J. 7. pp. 87–94, Feb., 1915. Paper read before the Am. Soc. Chem. Ind., Nov., 1914.)—Considers the effects of additions of Ti on steel and compares these with the effects of other deoxidising agents. Titanium in the form of carbide is most generally used for additions to steel. It is shown that for general effectiveness, Ti is the best of the various deoxidisers used. The chief objection to the use of Al is said to be its harmful effect in hindering the removal of oxide and slag from the metal; there are similar objections to Si, but titanium oxide acts as a flux for silicates and assists their removal from the metal. Under the usual conditions of manufacture, it is very difficult to make steel absorb more than 0·025 % Ti. Generally speaking 13 lbs. of the ferrocarbon-titanium alloy containing 15 % Ti is the amount recommended per ton of steel to be treated, and this is added to the melted steel as it flows from the furnace to the ladle. In most rail steel that has been properly treated with Ti, very small, hard, angular, pink inclusions can be found under the microscope, which consist of titanium nitride, possibly contaminated with carbide. A table of results of mechanical tests on untreated and titanium-treated steels is given. C. O. B.

612. *Allotropy of Cadmium.* V. *Heat of Transformation in the Reaction α-Cd $\rightleftarrows$ γ-Cd.* **E. Cohen** and **W. D. Helderman.** (K. Akad. Amsterdam, Proc. 17. pp. 1050–1054, Feb. 27, 1915.)—Measurement of the heat of transformation of α- into γ-cadmium [Abs. 508 (1915)] by the calorimetric method being impracticable, the authors make use of a transition cell of the sixth kind as described by Cohen. In such a cell the electrodes consist of a metal in its stable and metastable modifications respectively, immersed in a solution of arbitrary concentration of a salt of the metal. For the purposes of certain other measurements, two separate cells were employed, one containing α-Cd and the other γ-Cd, immersed in an unsaturated cadmium sulphate solution, the other electrode being 8 % cadmium amalgam in each case. The results were calculated by means of the Gibbs-Helmholtz equation, $E_\theta = E_c/n\epsilon + T\,dE_c/dT$. It is found that the transformation of 1 gm.-atom of α-Cd into γ-Cd at 18° is accompanied by absorption of 739 gm. cals., and that the metastable transition point of the reaction α-Cd $\rightleftarrows$ γ-Cd is 94·8°.

T. H. P.

613. *Physical Properties of Isotopes.* **F. A. Lindemann.** (Nature, 95. pp. 7–8, March 4, 1915.)—The author deduces several interesting results as to the structure of the atom. Two elements of different atomic weights must differ either in their chemical or physical properties. If elements are inseparable chemically their affinity must be equal, and, consequently, their atomic frequency ν must be identical. But as ν is a function of the atomic weight and of the forces acting between the atoms, the latter must vary when the atomic weights are different. From such considerations the author calculates that if the molecular weights of two kinds of lead vary by 0·26 % there should be a difference in vapour pressure amounting to 20 % at 100° C. Again, the vapour pressure of RaD (atomic weight = 210) should be about 2·6 times less than that of ordinary lead at 100° C. Measurement of melting-points is suggested as another possible test. Thus the melting-point of Soddy's lead [see Abs. 502 (1915)] should be 1·54° C. higher than that of ordinary lead. Assuming the atomic weight of the end product of the thorium series to be 208·4, this difference should amount to 3·75° C.

The following conclusions on the structure of the atom are given:—" The purely chemical properties are determined by the external electrons, which probably also account for the apparent radius of the atom. The forces of attraction and repulsion between the atoms, the interaction of which results in the solid state, have their origin in the nucleus. In isotopes they are proportional to the atomic weight, *i.e.* probably to the number of positive particles. It is simplest to assume that the nuclei of isotopes differ in their linear dimensions, but not at all, or only very little, in the arrangement of the particles." A. B. W.

614. *Action of Lead, Copper, Tin, Nickel, Zinc, and Aluminium on Water.* **W. P. Jorissen.** (Report of the XI. Internat. Pharmaceutical Congress, Leiden, 1913. Chem. News, 111. pp. 56–58, Jan. 29; 67–70, Feb. 5; 78–80, Feb. 12, and pp. 91–92, Feb. 19, 1915.)—The object of the investigation is to study the behaviour of metals when in contact with water, particularly ordinary water containing both air and salts; sea-water and dilute acids are also considered. When the metals are arranged as to the potentials which they assume in normal solutions of their salts, Mg is at the positive, and Au at the negative end, the order being: Mg, Al, Mn, Zn, Cd, Fe, Co, Ni, Sn, Pb, H, Cu, Bi, Sb, Hg, Ag, Pt, Au; the potentials are referred to the hydrogen electrode. The order is affected, however, by the salt selected and by the presence of air. The position of ordinary Al is uncertain, because it coats itself with a film of oxide; the position indicated is that of amalgamated Al. Particulars are given of the metals mentioned. Iron is not especially referred to as it has a literature of its own; but polarisation and overvoltage are discussed. The action of potable water on lead and zinc cannot be predicted from the composition of the water.

There are many literature references. H. B.

615. *Electrode and Diffusion Potentials.* **G. W. Moffitt.** (Phys. Rev. 5. pp. 31–34, Jan., 1915.)—From the results of the author's previous work [Abs. 2013 (1913)] it seems reasonable to suppose that there exists at the clean boundary surface of a liquid and air a certain p.d. which in certain cases may be zero. Thomson's work on the electricity of drops (Phil. Mag. Ser. 5. 37. p. 341, 1894) points to the same conclusion from entirely different experimental evidence, and the same is the case with McTaggart's results [see Abs. 958 (1914)]. Further, it may be assumed that conditions of electrical neutrality are the same for drops as for a clean level surface of the same liquid, and that solutions may be selected by the falling-drop method for which the air-liquid p.d.'s are negligibly small. The author has now examined, by means of an apparatus similar to that used by Thomson, the liquids with which he worked previously. A sensitive Dolezalek electrometer was used to detect the presence of charges, one pair of quadrants being earthed and the other pair connected by means of a small copper wire to the solution in an insulated glass funnel, from which the drops fall on a brass plate elevated from the bottom of a brass vessel in which the solution accumulates. This brass vessel was insulated and connected to the insulated quadrants. To remove the charged air, a piece of brass tubing, flattened at one end, was placed horizontally just above the brass plate and a few inches from the side of the brass vessel. This tube maintained a gentle, steady stream of air over the vessel. With distilled water a positive charge accumulated rapidly, but with N-, 0·5 N-, and 0·1 N-solutions of sodium chloride, bromide or sulphate, or copper chloride or sulphate, no charging effect occurred. Consequently, the values given by the author (*loc. cit.*, p. 106)

are, except in the case of zero concentration, the sum of the constant plate surface potential and of the liquid-metal potential, whilst those given on p. 107 are the diffusion p.d.'s. It is not clear why the anion should not affect the electrode potential, and it seems more probable that in general the anion does exert some influence, and that for the dilute solutions employed in concentration cells the effect at one electrode may be very nearly balanced by the oppositely directed effect at the other. T. H. P.

616. *Reproducibility of the Copper Electrode.* **F. H. Getman.** (Am. Electrochem. Soc., Trans. 26. pp. 67–74; Disc., 74–78, 1914.)—It appears to be quite a general phenomenon that there is a variation in the p.d. between the common metals and solutions of their salts, but in no case is this variation more marked than with copper electrodes [compare Abs. 1936 (1914)]. It is not uncommon to find two copper electrodes prepared in identically the same manner differing by as much as 10 millivolts. In order to find a reason for this variation the author has studied the following copper electrodes, the electrolyte in all cases being a solution of copper sulphate: Electrolytic copper wires, 3 mm. in diam.; Pt plates covered with a uniform and adherent electrolytic deposit of copper; electrolytic copper wires 1 mm. in diam.; fine Pt loops covered with a deposit of spongy copper obtained by electrolysing a neutral solution of copper sulphate at high current density; electrolytic copper wires 1 mm. in diam. and embedded in Kahlbaum's copper powder. The only electrode which was constant and reproducible was that in which spongy copper was used. From experiments on electrodes of massive copper, in which the electrode was subjected to varying preliminary treatments, such as, polishing with an emery cloth, hammering for 5 minutes, or heating to redness and then quenching, the author concludes that the hypothesis of strain in the massive copper is inadequate to explain the observed differences. They may be accounted for by the assumption that massive copper is in a condition of metastability, as pointed out by Cohen and his co-workers. The spongy modification of the metal is to be regarded as the stable modification under the ordinary laboratory conditions. T. S. P.

617. *Electrolytic Deposition of Copper-Tin Bronzes.* **R. Kreemann, C. T. Suchy, J. Lorber,** and **R. Maas.** (Monatshefte d. Chemie, 35. pp. 219–288, 1914.)—The experiments were conducted on the same lines as those described in the previous investigation [Ibid. 34. p. 1757, 1913], potential measurements being first carried out in order to determine with what concentrations and under what conditions the deposition potentials of the two metals were close together. Baths made up from copper sulphate, stannous chloride, and ammonia solutions, with or without the addition of sodium hydroxide and ammonium chloride, did not give satisfactory results, but bronze could be deposited either from tartrate or cyanide baths, a necessary condition for a good deposit in sheet form being a high content of free alkali hydroxide. As the content of alkali increases, the deposits become more elastic, and contain less hydrogen and cuprous oxide. With high concentrations of alkali hydroxide, however, the copper anode becomes passive, and accompanying this passivification, especially in tartrate baths, decomposition of the electrolyte takes place, thus limiting the length of time the bath may be used to a few days. There is an optimum alkali concentration which gives the best results. The decomposition in the tartrate baths is due to oxidation of the tartaric acid and subsequent reduction of the copper salt.

Investigation of the microscopic structure, of the e.m.f., and of the sclerometric hardness of the deposits, showed that the bronzes obtained from the cyanide baths were more uniform in structure than those from the tartrate baths.

Technically, owing to the decomposition of the tartrate baths and the less uniform structure of the deposits, the cyanide baths are to be preferred.

T. S. P.

618. *Electrolytic Separation of the Rare Earths.* **L. M. Dennis** and **B. J. Lemon.** (Am. Chem. Soc., J. 37. pp. 131–137, Jan., 1915.)—Krüss observed in 1893 that the electrolysis of mixtures of rare earths deposited hydrates at the kathode, and that the different constituents of impure yttria could be separated in this way. The authors experiment with earths of the didymium and yttrium groups, obtained from the Welsbach Co., on similar lines. With stationary electrodes the resistance of the bath soon became too great, because the kathode became coated with hydrates. Experiments with a rotating kathode, cylinder of copper partly dipping into the solution and provided with a scraper, did not succeed. The authors then placed mercury in a beaker, to a depth of 3 cm., and stirred the mercury by blowing air through it. The anode is of platinum. The oxides are dissolved in nitric acid, evaporated to dryness and taken up with water, and the solution is poured on the mercury. After electrolysis for 6 hours at 9 volts, the settled solution is siphoned off and again electrolysed in the same manner. The precipitates are freed from mercury (by H_2S) and converted into oxalates, which are ignited for atomic-weight determinations; the fractionation is also controlled by spectroscopic analysis. In this way lanthanum has been separated, by 10 fractional electrolyses, from didymium and also from praseodymium, and erbium from yttrium. According to U.S. Pat. No. 1,115,513 (Met. and Chem. Engin. 12. p. 791, Dec., 1914. Abstract) L. M. Dennis separates erbia from yttria by two or more electrolyses.

H. B.

619. *Electrodeposition of Lead from Lead Acetate Solutions.* **F. C. Mathers.** (Am. Electrochem. Soc., Trans. 26. pp. 99–116, 1914.)—[See Abs. 2018 (1913), 794 (1914)]. Experiments with some new addition agents are described by means of which smooth, finely crystalline deposits of lead may be obtained from acetate baths. These deposits are much superior to those obtained with peptone as an addition agent. For each litre of bath there should be used 100 gm. of lead acetate, 40 gm. of ammonium perchlorate, 25–50 c.cm. of glacial acetic acid and addition substance prepared by one of the following methods. (1) Boil for 2 hours 25 gm. of poplar-wood sawdust in the glacial acetic acid diluted with an equal volume of water. Add this extract to the solution of the lead acetate and ammonium perchlorate. Filter, dilute to 1 litre and electrolyse. (2) Boil 50 gm. of the poplar-wood sawdust with 400 cm. of water for 8–10 hours, and add the extract to the bath. (3) Add to the lead bath the clear aqueous extract of 5 gm. of aloes with 200 c.cm. of warm water. (4) The insoluble tar or gum left after the extraction of 12·5 gm. of aloes with warm water, is dissolved in the glacial acetic acid and the solution added to the bath. Electrolyse without filtering. This is the best addition agent. (5) 10 gm. of the residue remaining after the commercial extraction of aloes in the manufacture of aloin are dissolved in the acetic acid and added to the bath.

A current density of 0·4 amp./dm.^{2} must be used for thick deposits. For thin deposits in plating 0·8 amp./dm.^{2} may be used. The current efficiencies at the anode and kathode are nearly 100 %. More of the addition substance and more acetic acid must be added to the bath during the course of the electrolysis. T. S. P.

620. *Electro-deposition of Tin from Tin Salts of Mineral Acids.* **F. C. Mathers** and **B. W. Cockrum.** (Am. Electrochem. Soc., Trans. 26. pp. 133–134; Disc., 134–135, 1914.)—In the attempt to obtain smooth, finely crystalline deposits of tin from tin salts and mineral acids, the authors have made experiments with 179 various combinations of conditions and compositions of baths, but no entirely satisfactory deposit has been obtained. The baths contained 4 % of tin as stannous chloride, fluoride, perchlorate, or fluoborate, or as stannic chloride, about 1 % of the respective free acids, and 0·05–0·5 % of various addition agents. The best deposits were obtained at room temperature from stannous fluoborate saturated with clove oil or containing 0·1 % of digitalin, and from stannous perchlorate containing 0·1 % of phloridizin. The deposits were firm and free from loose trees or projections, but they were very crystalline. No one of the baths tried, however, forms a satisfactory tin plating or refining bath. T. S. P.

621. *Sources of Impurities in Kathode Copper.* **L. Addicks.** (Am. Electrochem. Soc., Trans. 26. pp. 51–61; Disc., 61–62, 1914. Met. and Chem. Eng. 12. pp. 706–708, Nov., 1914.)—The impurities present in electrolytically refined copper may be due to (*a*) deposition from the electrolyte, (*b*) inclusion of electrolyte in the crystalline structure of the kathode, (*c*) mechanical contamination from anode slimes suspended in the electrolyte and attaching themselves to the kathode, and (*d*) substances entering the subsequent fusion of the kathodes from the furnace, fuel, tools, and other outside sources. The author has collected data from various sources in order to see if there is any connection between the impurities found in electrolytic copper and any of the above-mentioned sources of contamination. The conclusion arrived at is that the slimes, included electrolyte, and direct deposition, all have a hand in the fouling of the kathodes, but that definite values cannot be assigned to each factor. T. S. P.

622. *Electrolytic Separation of Zinc, Copper, and Iron from Arsenic.* **A. K. Balls** and **C. C. McDonnell.** (Ind. and Eng. Chem., J. 7. pp. 26–29, Jan., 1915.)—Zinc, iron, and copper may be separated electrolytically from arsenic by using an electrolyte containing a large excess of potassium or sodium hydroxide. The As must always be present in the higher state of oxidation. To the solution containing the metal and As is added 50 % potassium hydroxide solution until a clear solution results (tartaric acid is added in the case of iron and copper), and then a further excess of about 20 gm. of the alkali; the mixture is diluted to 95 c.cm. and submitted to electrolysis, a nickel basin being used for the kathode and a rotating Pt paddle for the anode. The addition to the electrolyte of 0·2 gm. of potassium nitrate renders the deposit more smooth and adherent, whilst 2 gm. of the nitrate may be added in the case of copper without appreciably interfering with the accuracy of the separation. The As may be estimated in the solution from the electrolysis. T. S. P.